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ABSTRACT

This publication is designed as a guide for the instructional program in science for grades 4-6. The first part contains performance goals and conceptual schemes. Emphasis is placed on the teaching of science as content and as process. The processes to be included and outlined are: observing, classifying, communicating, measuring, inferring, predicting, identifying and controlling variables; formulating hypotheses; using and formulating operational definitions; using and formulating models; and experimenting. Laboratory work is stressed where the classroom and the community as a whole serve as a field of experimentation for children. The interrelation of science with other areas of the curriculum is encouraged, especially those learning activities which are appropriate for career motivation. The roles of the teacher and the principal are stated. The units in the guide are not grade-placed but represent a three-year span, grades 4-6. They include the three major strands of science: Physical, Earth, and Life Science. For each strand, the concept, performance objectives, materials, and learning activities are stated in detail. Evaluation is to be broad and continuous but in an informal manner. (GA)

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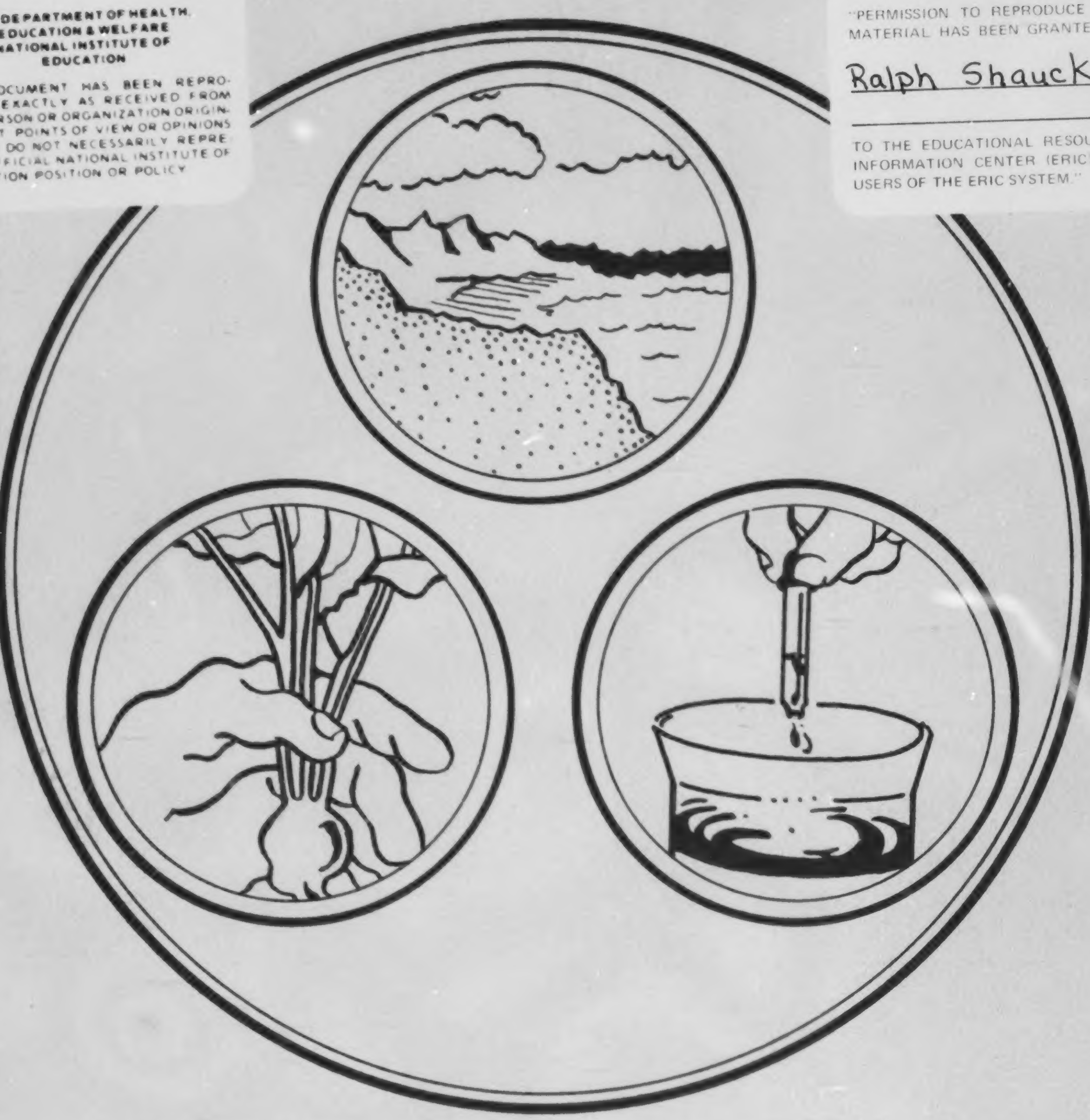

SCIENCE

Curriculum Bulletin Number 26

CINCINNATI PUBLIC SCHOOLS
Grades 4-6
1976

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SCIENCE CURRICULUM GUIDE

INTERMEDIATE GRADES: 4 - 6

Department of Curriculum and Instruction
Cincinnati Public Schools

1977

FOREWORD

The Science Curriculum, 4-6, is a guide for the instructional program in science in the Cincinnati Public Schools. The units provide the teachers with background, activities, and resources used to develop pertinent science topics and promote sound educational practices.

A K-12 committee developed the conceptual schemes. A curriculum committee composed of intermediate teachers worked to develop this guide. Members of this committee are listed below.

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Jack Burch	1968-75
Gerald Levy	1968-69
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*Summer, 1975

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SCIENCE IN THE ELEMENTARY SCHOOL PROGRAM

Introduction

The scientific and technological revolution has produced an explosion of knowledge that has stimulated a rapidly changing society. Society, in turn, demands an education designed to meet the challenge of change. This requires citizens who understand the conceptual schemes and investigating procedures of science, and citizens who make political and social decisions based on science knowledge. The development of scientific literacy can be accomplished through a continual systematic program from kindergarten through grade 12.

Point of View

The study of science not only contributes to children's knowledge about the physical world but helps to develop thinking and inquiry skills which nurture their intellectual development.

In recent years, the emphasis in science education has been placed on the interaction of science and the learner. Science is both content and process. Process is the method of science. It involves thinking skills and the strategies of inquiry. Science processes are general learning skills that contribute to the total education of children. In a very real sense, children involved in science are learning how to learn. This curriculum is designed to involve children in a variety of processes that are essential in developing the inquiry skills through which facts and concepts are learned and attitudes and values are formed.

Goals

This science program reflects what is known about child development, the nature and needs of society, and the application of science in meeting the needs of children and society. It is directed toward the following goals:

1. To nurture the development of intellectual skills.

   As children work with objects and experience events in the physical environment, they are confronted with problem situations. These arouse their curiosity, stimulate their interest, and motivate them to seek solutions and understanding. As children investigate, gather evidence, evaluate the evidence and draw conclusions, they are challenged to think logically and critically.

2. To help children develop skills in using the processes of science.

   Children learn by thinking about those objects and events they have perceived through their senses. As they observe, describe, classify, record, interpret, infer, hypothesize, experiment, and draw conclusions, they are using the same processes scientists use. Processes cannot be taught directly or vicariously. As children engage in many direct experiences with objects and events, they begin to internalize the science processes.

3. To help children develop science concepts.

   Concepts are ideas and principles which provide the basis for interpreting many events. Facts and information should not be memorized, but serve as input for the development of concepts. Concepts developed through inquiry and discovery, generally, are more vivid and more durable than those told to children.

4. To help children develop attitudes and values consistent with the processes and content of science.

   Science experiences help children develop objectivity and open-mindedness. Science experiences enable children to view problems from more than one frame of reference, consider the ideas of others, develop the willingness to change their minds in light of new evidence, distinguish between fact and fancy and deal rationally with problems.

5. To help children develop appreciations and values.

   There are many aspects of science which children should learn to appreciate. For example, the contributions people have made to the body of science knowledge, the patterns and regularity of the universe, and the beauty in nature. Science should nurture respect for life and should be directed toward improving the quality of life.

6. To apply science to the world in which we live.

   The teacher must make science relevant to the children and stress its relationship to the real world. Efforts should be directed toward building understanding of the nature of modern technology and its impact on the environment of the earth and the universe. Conservation of irreplaceable natural resources and protection of endangered species are vital.

7. To educate pupils of varied needs.

   Science education is directed toward building scientific literacy in our society as a whole. This includes the college-bound, the science oriented worker, the non-science oriented worker, and the general citizenry. It should contribute to their sense of satisfaction in leisure time pursuits.

Conceptual Schemes, K-12

This curriculum, 4-6, is based on conceptual schemes developed K-12. Conceptual schemes are invented by man. They are formed by relating many concepts to a larger, more encompassing whole. Probably the most unchanging conceptual scheme is that everything in the universe is in constant change. These conceptual schemes are not concepts to be taught directly to children, but are broad generalizations upon which the topics and learning activities have been built, K-12. These schemes cut across the various strands of science -- life, physical, and earth. As children progress from kindergarten through the secondary schools, science education will center on these conceptual schemes. Obviously, the treatment and depth of understanding will vary with children of differing ages and abilities.

The following schemes serve as a rationale for the content and objectives of the curriculum.

There is a relationship between structure and function.

All life affects and is affected by the interactions that occur in the universe.

The sum of matter and energy in the universe remains constant.

The universe is in continuous interaction and change.

The knowledge of processes of science are accumulating at an ever-increasing rate.

Matter and energy in the universe exist in units, kinds, and forms of varying sizes and complexity.

Man uses the knowledge and processes of science for decision-making and to regulate the environment.

Science and technology have created many career opportunities.

Processes in Science, K-6

Science is both content and process. Content refers to the body of science knowledge - facts, concepts, and generalizations. It consists of objects and events in the physical world. Processes are the methods by which one obtains knowledge. Experiences with objects and events enable the child to acquire the processes that are essential for learning of science content. By using the processes, the child learns how to learn. A child cannot be expected to learn all there is to know about science. It is the school's responsibility to help each child acquire the skills and processes necessary to obtain information. Processes are learned by the child "doing," not by the teacher "telling."

The following processes emphasized in the 4-6 science curriculum are based upon those developed K-3. The processes appear in the suggested learning activities and in the instructional objectives.

Observing. Observing is more than seeing. It involves the use of all our senses. Some basic ideas to remember when observing are:

1. Use as many senses as possible. Look, feel, taste, smell, listen, crush, shake, press, and lift. Classify observations by the sense used.

2. Observe likenesses and differences when comparing two or more objects and when observing objects undergoing change.

3. Quantify observations. The size or number of objects is usually important.

4. Distinguish between an observation and an inference. Observations must be limited to properties which can be detected with the senses. Inferences are assumptions.

5. Utilize instruments such as a thermometer or an equal arm balance to extend observations of the senses.

Classifying. Classifying gives order to a collection of objects or events. Classifying occurs in daily activities - words in a reading lesson; foods by fruits or vegtables; organisms by plants or animals; rocks by color or hardness; stars by magnitude or color; and music by high or low pitch. In classifying objects three questions are pertinent.

1. What properties of the objects may be used to classify them?

2. Is there more than one way to classify the set of objects?

3. Which classification is more useful?

The following ways to classify are arranged from easy to more difficult.

1. Group Inclusion. Place an object in a proper category. Recognize that an object has the property of the category in which it is placed, for example: if the category is furniture, a chair will be classified as furniture while a tricycle will not.

2. Dual Membership. Recognize that objects can and do have many properties and can be placed in more than one category, for example: a cow is a mammal, but is also a female.

3. Serial Ordering. Order (seriate) objects into a sequence. Choose a property by which to order the objects, for example: length - shortest to longest; intensity or brightness - lightest to darkest; texture - smoothest to roughest.

Communicating. Communicating involves recording and interpreting data to others in spoken word and written form. In order to exchange ideas and information, precise language is important. Firsthand experiences, direct observation, study prints, filmstrips, films, filmloops, tapes, and printed reference materials (books, dictionaries, and glossaries) are sources of information and ideas.

The following are illustrative ways to record in science:

- Labels for objects, pictures, diagrams
- Rebus sentences
- Descriptions of observations
- Experience charts
- Records of observations
  - Picture stories
  - Data sheets
  - Graphs (pictograph, bar, and line graphs and histogram)
  - Sequential directions for making investigations
  - Specialized vocabulary

Learning to read and interpret data is as important as learning to communicate and record. Hypotheses can be made and conclusions drawn from interpretations of recorded data. These reading skills are especially significant in science.

Measuring. Measuring is concerned with quantifying some property of an object or event. Properties often measured are length, mass, time, and temperature. Measuring is an integral part of science, both rough and precise measurements are required. The use of the metric system is increasing. Metric units are used in activities when deemed appropriate. The following sequence of measuring skills has relevance in elementary science.

1. Comparing the quantity of some common property of two objects, such as length, mass, or volume. The result is a "more than - less than" comparison.

2. Ordering (seriating) three or more objects by some common property, for example: smallest to largest; shortest to longest; thinnest to widest.

3. Measuring a property of an object by using an arbitrary non-standard unit, such as a hand or foot.

4. Measuring a property of an object by some standard unit, such as foot, pound, meter, gram, or degrees.

5. Estimating measurements to assist in approximating a quantity.

Inferring. Observations are made by using the senses. Inferences are ideas, explanations, or assumptions based on observations. Many different inferences may be made from a single observation. All inferences are not correct. Incorrect inferences are often the result of insufficient observations and insufficient evidence. Some inferences can be tested more directly than others.

Predicting. Predictions are forecasts of future observations. Predictions are based on past observations of events that have a regularity in their pattern; such as sunrise and sunset. Observations, measurements, and past inferences provide evidence necessary for predicting. The more evidence a person has about the regularity of events, the more confidence he can place in his predictions. He begins to realize that nature is not capricious.

Interpolation is making predictions of a value between two known values. Interpolation can be made quickly between two known points on a graph. If a substance dissolves in 20 seconds at 30 degrees and in 10 seconds at 40 degrees, one can interpolate that it would dissolve in 15 seconds at 35 degrees.

Extrapolation is making predictions by extending the pattern of values on a data sheet or graph beyond what has been recorded. If 20 milliliters of a substance weighs 30 grams and 30 milliliters weighs 45 grams, then one can extrapolate that 40 milliliters would weigh 60 grams.

Identifying and Controlling Variables. A variable is a part of an event which has influence on it. A variable may be an object, a condition, or a force. Children are able to identify variables long before they can control them. Identifying variables is often a matter of finding out what is different about two specific objects or events. "Why does one bicycle coast farther than another?" (Possible variable: weight of the rider; or amount of friction.) "Why did the water in glass A dissolve more sugar than the water in glass B?" (Possible variables: temperature of the water, or volume of water.) A histogram is an important device for identifying variables.

Controlling variables is an essential part of designing an experiment. The following terms may clarify how variables may be handled in an experiment:

1. Constant - A variable may be held constant, that is, some factor which is capable of influencing an event is presented in all trials so that the influences of other variables can be tested. A controlled variable is called a constant.

2. Manipulated Variable - a manipulated variable is the variable that is controlled but varied by the will of the investigator. It is also called an independent variable.

3. Responding Variable - A responding variable is controlled but varied by the manipulated variable. It is also called a dependent variable.

Formulating Hypotheses. Hypotheses are generalized statements. Inferences refer to specific examples. It is an inference to say, "This balloon expanded because the gas in it was heated." It is a hypotheses to say, "Gases expand when heated."

People make many inferences and hypotheses. Testing hypotheses involves identifying and controlling variables and designing experiments.

Using and Formulating Operational Definitions. An operational definition specifies the evidence necessary to clarify the meanings of words. To be helpful to children, definitions must be related to their own experiences. It is tempting for a teacher to impose a definition on a child. It is valuable for children to formulate their own definitions when possible.

A liter is a unit of volume in the metric system. (Not an operational definition)

A liter is the volume of one kilogram of distilled water at 4° Celsius. (Operational definition)

An operational definition may be formulated in the following ways:

1. Describe what the object does or how it operates, for example: a complete electric circuit - two wires, a dry cell, and a bulb are arranged so the bulb lights.

2. Describe what the object looks like, for example: a complete electric circuit - one wire connects one terminal of a bulb to one terminal of a battery and another wire connects the second terminal of the bulb to the second terminal of the battery.

3. Describe the action, for example: a complete electric circuit - join a terminal of the battery to a terminal of the bulb with a wire and use second wire to join the other terminal of the battery to the other terminal of the bulb.

A definition is ambiguous if some other object fits the definition, for example: to define a flower as "a part of a plant" is ambiguous because there are other parts of a plant that are not flowers.

Using and Formulating Models. A model is an inference or hypothesis which attempts to explain a set of observations. Models are used to communicate unconfirmed explanations or observations and explain phenomena that we cannot observe. The idea of molecules and the explanation of the behavior of molecules are models. As long as the phenomena can be explained by the model, the model is good. Models must be modified when data is collected which is inconsistent with the model.

Experimenting. Experimenting involves all the processes mentioned in the foregoing and more. It involves the honesty, the bias, the hunches, the determination,the insight, and the will of the experimenter - and probably a great deal more. Designing experiments can be simple or very complex. There are many pitfalls, the most frequent of which is not identifying and controlling variables.

The following are a few important points about experimenting:

1. Experiments are designed to test inferences, predictions, or hypotheses. They may also be designed to determine which of various objects or set of objects behave in a prescribed way. For example, if one wishes to know which of two materials is a better conductor of heat, the experiment is designed without a hypothesis. However, a hypothesis may be constructed for the experiment - namely, "Copper is a better conductor of heat than glass."

2. All variables which can have any influence on the results must be kept constant except for those being manipulated or those that are expected to respond.

3. More than one interpretation may be made from a given set of observations. Other tests often need to be made to check the hypotheses or inferences suggested by the various interpretations.

4. Results of experiments should be recorded to enable others to replicate the experiment.

Classroom as a Laboratory

The science program today is laboratory oriented with an emphasis on observation, experimentation, and the search for order, regularity, and causality. Science learning is object centered. Children should use equipment and materials to explore various aspects of natural phenomena in a laboratory setting. This means that every classroom should have a variety of concrete materials. Since it is impossible for children to experience directly all aspects of science, there is a need for study prints, films, filmstrips, and books for reference. These reinforce and extend children's experiences with concrete materials.

Interest centers devoted to specific areas of science should be part of every science classroom. Each science classroom should have at least one aquarium and one terrarium. Animals in cages, plants in pots, manipulative materials, filmstrips, cassettes, and books are important components of the centers. Interest centers may be used as on-going or spare time activities. A display area is desirable for children to share items of interest and gives dignity to collections they bring to school.

Provision for storing materials must also be considered. A systematic organization is needed so children know where materials are housed. They should be taught how to distribute materials and how to clean-up after using the materials. Chemicals should be placed in locked cupboards inaccessible to children.

Community as a Laboratory

Science learning should extend beyond the walls of the classroom. Too often children learn they "go outside to play and come back inside to work." It is important to teach children the value of the outdoors as a place to learn. They spend many hours outside school. They must be helped to understand what they can learn from their own observations outdoors. Activities outdoors make learning more a part of children's normal experiences and help them transfer what they learn in school to the real world setting.

Attention should be given in the local school to develop the school site as a resource for outdoor learning experiences. Even if the school grounds have concrete or blacktop, cracks in the pavement and small areas planted with flowers, shrubs, or trees can be utilized.

The science program should include a carefully planned and organized series of field trips for all children. Cincinnati is rich in community resources - The Cincinnati Zoo, Cincinnati Nature Center, Museum of Natural History, Spring Grove Cemetery, Krohn Conservatory, outdoor education centers, and parks. References to these and other specific community resources are in the learning activities. Each trip should be an integral part of the science program. Specific objectives, plans for learning experiences, and evaluative activities are necessary.

Not only should the classroom extend into the community, but the community should be brought into the classroom. Community resource people should be invited to contribute to children's understanding of the topic being studied and offer insights into career implications. References to specific kinds of resource people are given in the learning activities.

Science and Other Curriculum Areas

It is important that the teacher see the relationships among the various areas of the curriculum and interrelate them when feasible. As children work with objects and describe their properties, it is only natural that much descriptive oral language develops. It is suggested that the teacher use a language-experience approach in the science program. As children have many firsthand experiences, the teacher is encouraged to record words on charts. Children and teacher should read the words together. New words should be added to the chart throughout the year. These charts then serve as wordbooks for reading and creative writing. Many ideas for chart-making have been included in this curriculum guide.

Suggestions are also given for children to engage in reading activities. Functional reading is involved as they follow directions to carry out a learning activity from a text or a chart. Many activities require a child to use reference books and other media to obtain information.

As children record findings from their observations, they begin to realize the need for communicating with others. Communication may take the form of pictures, written records, or graphs.

Frequently, children need to use mathematics in science. They quantify data, read thermometers, graph the kind of weather, chart the growth of a plant, and read scales. The teacher needs to be aware of these opportunities so that children may apply mathematics learning in a science context.

Career Motivation

For the elementary school child, work refers to tasks at school and at home for which he has assumed responsibility. Career motivation is an integral part of the total program of science in the intermediate grades. The general goals of career motivation are the following:

To create an awareness and understanding of the world of work.
To develop a positive attitude toward the world of work.
To inspire an appreciation of and respect for all honest work.
To create a desire to be a part of the world of work.

In reality, most activities in the science program have direct or indirect applications to the idea of work in general, and specifically, to the objectives of the career motivation program. These applications are as follows:

To complete tasks.
To work together in groups.
To use tools, equipment, reference materials, and human resources.
To make choices.
To learn skills of working with objects, data and people.
To learn about jobs and other human activities from special projects, resource people, and field trips.
To deal theoretically and practically with reality.

Specfic career motivation activities are included in each of the units of the science curriculum. These are indicated by a number sign (#) preceding an activity which is:

a self-evident career motivation activity,
a related idea which can be extended or treated in depth,

a learning situation within which career motivation activities may be included.

Role of the Teacher

The teacher's role is to guide children through many varied experiences and to motivate them to think. The role is that of a facilitator, rather than a dispenser of information. The focus is upon children as they investigate objects and events and interact with other children and the teacher. The teacher provides the physical and psychological environments that motivate and enable them to learn. The physical environment is described in "The Classroom as a Laboratory," The psychological environment is equally important. The teacher sets the tone for a comfortable, encouraging, and stimulating climate.

The teacher guides thinking through skillful questioning which will bring forth many kinds of responses - facts, generalizations, opinions, and values. It is relatively easy to ask questions which call for specific facts. These questions usually have only one correct answer and test a child's memory rather than understanding. Questions which have more than one right answer cause a child to think as he generalizes, and uses concepts and processes. Usually, the teacher should accept responses without giving a value judgment so that the flow of ideas may be kept open. Further experiences provide opportunity for children to modify and correct their ideas.

The following questions may help teachers assess the phychological environment in their classrooms.

Am I accepting of children?
Do my questions cause children to think?
Do I accept their responses?
Do my responses encourage or discourage children?
Do I provide concrete experiences before developing abstract concepts?
Have I provided sufficient instruction?
Do I provide opportunities for children to explore and create on their own?
Do I help children relate school experiences to their real world?

Role of the Principal

As the instructional leader in the local school, the principal establishes an environment conducive to learning science. The principal should:

Recognize the importance of science experiences to children's lives.
Recognize the importance of science to a technological society.
Support the teacher in correlating science and other areas of the curriculum.
Ensure ample time in the schedule for teaching science.
Secure needed materials to provide a stimulating science program.
Encourage the use of manipulative materials and living organisms in the classroom.
Plan for use of school grounds for outdoor science experiences.

Organization of the Guide

The science curriculum for the intermediate grades is divided into three sections representing the major strands of science - Physical, Earth, and Life Science. The units in each section are developed in the form of resource guides. They are not grade-placed, but represent a three year span, grades 4-6. It is not expected that a teacher would develop all units with a given class of children. At the local school level, teachers of science are encouraged to plan the science program longitudinally. It is desirable that teachers include units from the Physical, Earth, and Life Science sections in each year's plan. This should ensure variety and balance in the child's science program.

Each unit is organized into the following components: Background; Rationale; Glossary of Concepts; Investigations; Bibliography; and Mediography.

"Background" consists of science information pertinent to the topic to be developed. The material chosen for the background is not all-inclusive. It is designed to serve as a "finger-tip" reference for the teacher. It is suggested the teacher read this material carefully before launching the topic with children. The material in this section is not meant to be used directly with children. However, in some instances, the teacher may modify the teacher background material for student use, preferably after the laboratory experiences are completed.

"Rationale" describes the design of the unit in terms of desired pupil outcomes. It also points out some characteristics of the child and the relationship of these to science. The child's play activities, interests, and curiosity about his environment are considered as they relate to the topic.

"Glossary of Concepts" includes the main science ideas related to the topic to be developed. The concepts are listed in order of their introduction in the unit. A brief explanation or definition is included for each concept listed. The concepts serve as a guideline for the teacher. They are not to be memorized by the children. The intermediate curriculum, grades 4-6, builds upon the concepts included in the K-3 course of study and provides a foundation for science education, 7-9.

"Investigations" form the heart of the units. They include: Instructional Objectives; Concepts; Materials Needed, and Learning Activities.

"Instructional Objectives" have been written to serve as examples of evaluation. They may be utilized as a pre-test measure. If a teacher sets up the conditions for a instructional objective and children demonstrate they can meet requirements, the teacher may omit the learning activities for that concept and move on to the next. If children do not show reasonable success, the teacher will develop many learning experiences for a specific concept with the children and will utilize the instructional objective as a post-test measure. By utilizing the instructional objectives in this fashion, a child can enter at varying levels on the continuum of the concept development. Unneeded repetition can be avoided and the child's instructional time can be planned for more profitably. Some aspects of the program are more difficult to measure than others. Teacher observation is a valuable instrument.

"Concepts" and "Materials Needed" are given for each investigation. A variety of "Learning Activities" are provided to develop the concepts and to help students accomplish the objectives. In most instances, the learning activities progress from easy to more difficult. Teachers should choose the activities appropriate for the children's needs, abilities, and interests. Teachers are free to provide other activities that help children understand the concepts. It is important to remember that children usually need to experience many learning activities to develop understanding of a concept; otherwise, children may be verbalizing without understanding.

"Bibliography" contains suggestions for reference books for students and teachers.

"Mediography" contains suggestions for filmstrips, films, study prints, filmloops, and cassettes. These are intended for use as reference following the firsthand experiences suggested in the learning activities.

Evaluation

Evaluation is an integral part of the science program. It is a major tool in planning instruction, as well as determining its effectiveness. Evaluation must be persistent and continuous. Most assessment should be done informally. Teacher observation is a valuable instrument. As children interact with concrete materials, the teacher has a good opportunity to observe their behavior and assess the feedback.

Evaluation should be viewed broadly and include all aspects of child development. The teacher should assess: (1) Children's cognitive development. Can they describe the properties of a given object? (2) Children's development in the processes of science. Do they observe and record their data? (3) Children's attitudes. Do they turn off the faucets in order to conserve water? Do they remember not to cut across lawns? (4) Children's psychomotor skills. Are they developing fine muscles to pour liquids from one small container to another? Can they adjust the balance scale? Some aspects of the program are more difficult to measure than others.

The instructional objectives are stated in functional language. They focus on precisely what learners can be expected to do; however, the possession of science knowledge and the processes of science do not guarantee a change in children's behavior.

Time Allocation

The Ohio State minimum standards require that 4/5 of the school week be devoted to the basic subjects: reading, language, mathematics, social studies, science, and health. The amount of time allocated to each of these will vary from school to school. Ohio standards suggest a minimum time allotment of 120 minutes per week for science in grades 4-6. Intermediate grade schedules used in Cincinnati provide time allotments greater than the minimum. These standards should be followed to ensure that children will receive at least the minimum of science instruction.

PHYSICAL SCIENCE

PHYSICAL SCIENCE

The content of this section, Physical Science, is built around various aspects of matter and energy. Matter and energy are the two ways the universe reveals itself. Matter is the material, or the "stuff," of the universe. Energy is the property of matter that enables it to bring about change, motion, and force.

Matter and energy are related in many ways. Changes in matter require energy. For example: heat is necessary to change solids to liquids and liquids to gas. The transfer of energy often uses matter as a medium. For example: sound, heat, and electricity are transmitted through materials. Chemical reactions always involve energy transfer. In nuclear reactions, matter can be converted to energy and energy can be converted to matter.

The various forms of energy are interrelated. One form of energy can be converted to another. Mechanical energy is converted to heat when two objects are rubbed together. Electricity can be converted to heat, light, magnetism, motion, and sound. The temperature of a metal affects its ability to conduct electricity.

The Physical Science section of this curriculum guide is organized into seven units. One unit, Matter and Change,focuses on matter, its forms, its structure, its interactions, and its changes. The other units focus on specific kinds of energy - Sound, Light, Heat, Electricity, Magnetism, and Force, Motion, and Machines.

Each unit has been built around a concept structure adapted from concepts found in the Science Curriculum Improvement Study. These concepts form a hierarchy consistent with modern theories of child development. They are ordered from simple to complex and from concrete to abstract.

These concepts and their definitions are as follows:

Object	A piece of matter.
Property	A characteristic or attribute of an object.
Change	An alteration of form, composition, position, or other property of an object.
Interaction	The relation of objects that do something to one another.
System	A whole made of related parts; a group of objects that interact or serve a common function.
Variable	A part of a system or a condition that influences the behavior of a system; an object or condition that can change and differ from one system to another.
Reference Frame	An object used as a reference for relating the position and motion of another object.

Energy Source	An object or system that supplies energy to another system.
Energy Receiver	An object or system that receives energy from another system.
Model	A theory or explanation for a particular phenomenon that is not directly observable.

The first six of these concepts are introduced in the science curriculum for the primary grades. These concepts form a foundation for science experiences in the intermediate grades. All ten concepts are used extensively throughout all three sections of this curriculum guide.

Teachers may use these concepts along with the science processes listed in Science in the Elementary School Program as a guide in making decisions about which activities to teach. For example: younger, slow moving children may be able to name properties and identify variables but would not be able to control variables in an experiment or to formulate models. Older and faster moving students will be able to work with more of the concepts and activities.

MATTER AND CHANGE

Background

Matter is anything that has mass and occupies space. All objects are composed of matter. Any recognizable kind of matter is a material.

Properties and Change. Materials are recognized and identified by specific attributes and characteristics called properties. Properties may be classified as physical or chemical.

Examples of physical properties are color, taste, odor, shape, texture, solubility, conductivity, and density. People use their senses to recognize certain kinds of matter by their physical properties. We recognize brass by its color, salt by its taste, and vinegar by its odor.

A physical change is a change in a physical property of a material. This change does not alter the composition of the material. Melting ice, grinding wheat into flour, and eroding soil are examples of physical change.

Chemical properties describe how materials act when they undergo chemical change. A chemical change is an alteration of the composition of substances as they interact with one another. The combining of oxygen and iron to form rust is an example of chemical change.

Changes require the transfer of energy. A change occurs when one of more objects give up energy (the energy source) to one or more other objects (the energy receiver).

Substances. A substance is a material that always has the same composition and the same properties. Substances are either elements or compounds. Elements are basic substances from which all other substances are composed. Compounds are chemical combinations of two or more elements. Water is a compound composed of the elements hydrogen and oxygen. There are over one hundred known elements, ninety-two of which are found naturally in the earth. There are countless numbers of compounds. New compounds are frequently being discovered or made.

Phases of Matter. Matter exists in solid, liquid, or gaseous form depending upon its temperature. These three forms are called phases or states. All substances do not normally appear in all three phases. Many solid substances decompose or go through some other chemical change at high temperatures and never reach a melting point. Some substances, such as camphor, sublime; that is, they change directly from a solid to a gas without ever becoming a liquid.

Mixtures. Elements and compounds are rarely found in pure form but are mixed with various quantities of other substances. Such materials are simply called mixtures. Mixtures vary greatly in form and content. In form, they may be solid, liquid, gaseous, or combinations of these. In content, they vary in composition, concentration, and uniformity. The components of mixtures may be separated by mechnical processes such as sifting, decanting, filtering, distilling, and crystallizing.

Structure of Matter. The structure of molecules, atoms, and the properties of electrons help explain the phenomena of chemical changes. Chemical changes occur in the outer rings of electrons that spin around the nucleus of an atom. Molecules are composed of two or more atoms joined together. The joining together is the result of the electrical charges of the atoms.

A molecule is the smallest particle of a compound and an atom is the smallest particle of an element. Atoms join together to form molecules. Elements join together to form compounds.

Changes in the nucleus of atoms may result in changing one element to another. In such nuclear reactions, some of the matter may be changed into energy or energy may be changed into matter.

Solutions. Solutions are uniform mixtures. Since matter in each phase may serve as either a solute or a solvent, there are nine possible combinations. Most of the examples with which children are familiar are solids dissolved in liquids. However, some other common examples are: water dissolving in air (liquid in gas); alcohol dissolving in water (liquid in liquid); and moth balls dissolving in air (solid in gas). Solid solutions, called alloys, are formed while in the liquid phase and are frozen into the solid phase. Liquid and gaseous solutions are transparent and have the appearance of a single substance.

A clear liquid can be identified as a solution if it can also be shown that more than one substance is present. The appearance of a residue after a liquid has evaporated is evidence that the liquid was a solution. Since the boiling points of various liquids are different, two liquids may be separated by fractional distillation.

Solutions may vary in concentration. A saturated solution contains all the solute it can contain in the presence of some undissolved solute. A super saturated solution can be made but is very unstable and will give up some of the solute easily and form a saturated solution.

Heat is a variable that affects the amount of solute a solvent will dissolve. The warmer the solvent, the more solute it will dissolve. Therefore, the concentration of a solute in a saturated solution depends upon the temperature of the solvent.

Suspensions. Suspensions are cloudy uneven mixtures. Some suspensions will settle, leaving a clear liquid above the sediment. Other suspensions, called colloids, are non-clearing. Cloudiness in a liquid is evidence that it is a suspension but does not eliminate the possibility that some material is dissolved in it.

Rationale

The concepts in this unit are among the most fundamental concepts in science. Matter and energy are the two ways which nature reveals itself to people and all other living organisms. Understanding matter and its changes is essential in coping with the physical environment.

This unit is designed to help students: (1) observe and describe matter in its many different forms; (2) recognize and investigate physical and chemical changes; (3) begin to understand the structure of matter and how it accounts for the behavior of matter.

Glossary of Concepts

Property	A characteristic or attribute of an object.
Material	A specific kind of matter.
Matter	Any material that has mass and takes up space; "stuff."
Phase of Matter	A form or state of matter - solid, liquid, or gas.
Physical Change	A change in the properties of a substance that does not alter its chemical composition.
Chemical Change	A change in a substance that alters its chemical composition.
Conservation	In any interaction involving a physical or a chemical change, the total quantity of matter and energy remains constant. Matter and energy cannot be created or destroyed, but can only be changed from one form to another.
Substance	Any material having a definite composition; an element or compound.
Element	A substance made only of itself.
Compound	A substance that is composed of two or more elements chemically united in definite proportions by weight.
Mixture	Two or more intermingled substances but not chemically combined.
Solution	A uniform mixture of two or more substances. The particles are evenly distributed and the mixture has the appearance of one substance.
Settling Suspension	A mixture of solid material and a liquid.
Colloidal Suspension	A suspension that does not settle upon standing.
Saturated Solution	A solution that contains all the solute it can in the presence of undissolved solute.
Solvent	A substance that dissolves another substance (solute) to form a solution.
Solute	A substance that is dissolved by another (solvent).

Decanting	To pour or draw off a liquid without disturbing the residue.
Evaporation	The process of changing a liquid to a gas.
Filtration	The process of separating the undissolved particles from a liquid by passing the liquid through a porous material called a filter.
Atom	The smallest particle of an element that has the properties of that element.
Molecule	Two or more atoms joined together.

Investigations

Instructional Objective	Concept
Given an object, describe it by its properties.	Property

Materials needed:

sugar cubes
object collection (buttons, bottle caps, twine, pipe cleaners, soda straws, popsicle sticks, crayons)
vials of white powders (sugar, salt, baking soda, corn starch, plaster of paris)
vials of liquids (mineral oil, liquid starch, vinegar, corn syrup)
cardboard trays
plastic or paper cups
hand lenses

Learning activities:

1. Distribute a sugar cube and a cup of water to each child. Ask the students to tell you all they can about the sugar cube. List all their comments on the chalkboard. Have them make the water and the sugar interact in some way and ask them to describe what happens. Hold a sugar cube with tweezers and heat one corner of it with a match. Have students describe what happens and add these comments to the list.

   Introduce the concept of "property" and define it. Help students identify the property words in the list they made. Help students distinguish between "property" and "use." Call attention to relative terms such as small, smooth, soft, light, and heavy. Point out, for example, that the sugar cube may be small when compared with a cup of coffee but large when compared with a grain of sugar.

2. Distribute other objects on a tray. Include a vial of powder and a vial of liquid. List the properties of each object. Have them observe the interactions of objects with one another and add more properties to the list. Let students name other objects in the room and give at least one property of each object.

3. Play "What's My Name." Divide the class into small groups. Have one child give a property of an object as the other children try to guess the name of the object. If no one names the object after the first property is given, the person should name another property. See who can obtain the right name of the object from the group by giving the fewest number of properties.

Instructional Objective	Concept
Given collection of objects, classify them by their properties.	Property

Materials needed:

for each student; one envelope with a collection of objects, suggested objects:

piece of wood
drinking straw
aluminum foil
nail
cloth
file cards
wax paper
tissue paper
writing paper
insulated wire
paper clip

Learning activities:

1. Distribute envelopes containing the objects listed above. Have students sort the objects into two groups by some property. Discuss the various properties students used to group the objects. Encourage students to use different properties to group the objects in many different ways.

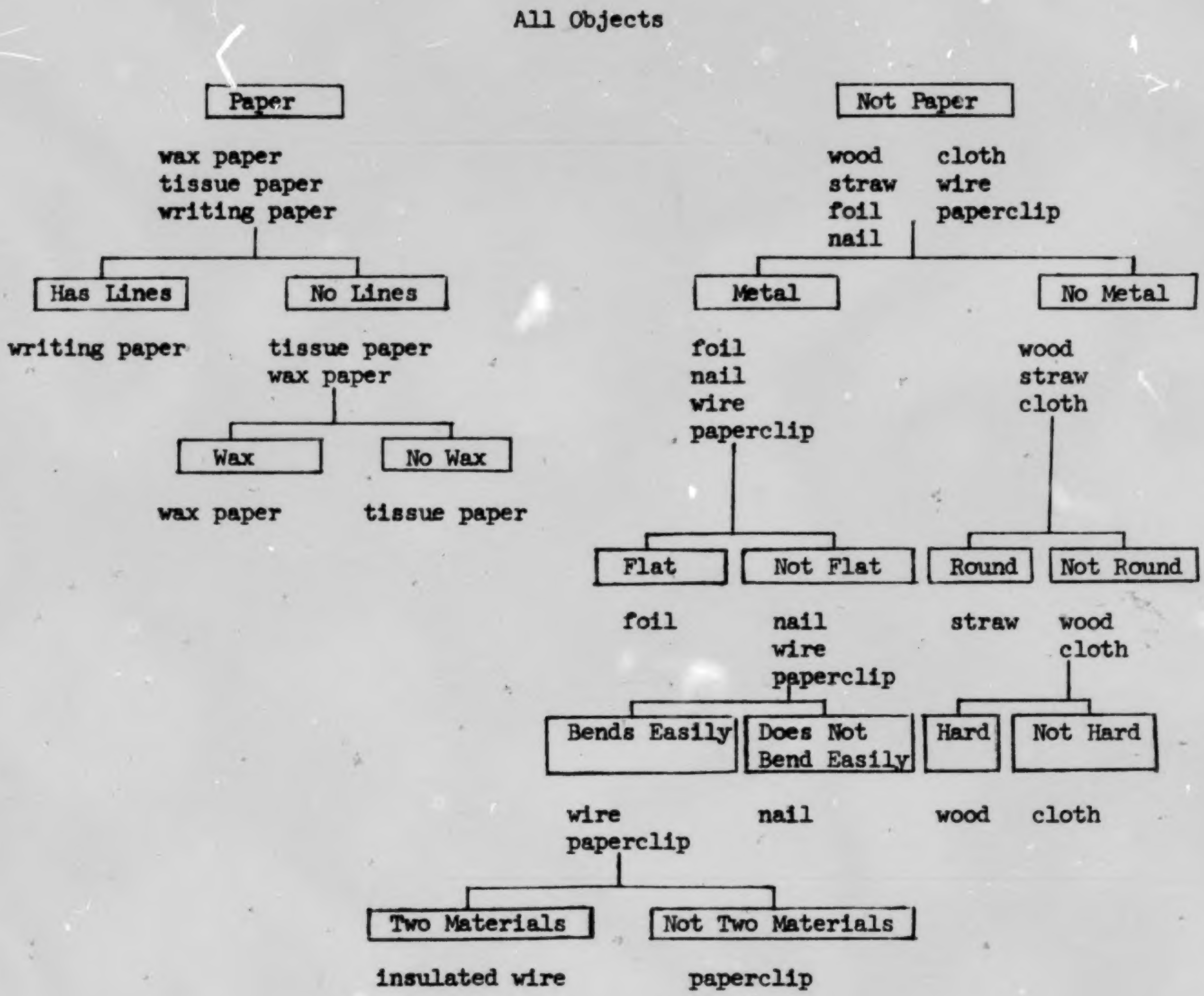
2. Help students to group the objects by more than one property.

   Help students to group objects using a "yes-no" classification system. For example, put all the objects that are made of paper in one group and those that are not made of paper in another group. By using other properties, have students make sub-groupings. Help them make a flow chart like the one on the next page.

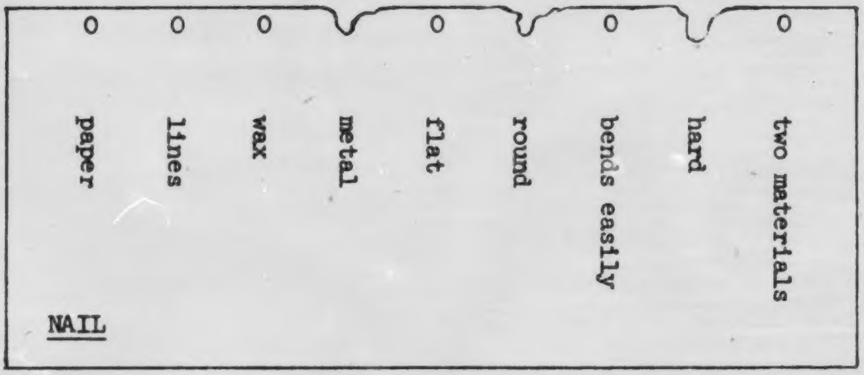
3. Another interesting classification system is the keysort. Prepare file cards by punching holes, evenly spaced, across one edge of the cards. Place the name of one object being classified on each card. Let each hole represent one property. Tear out a piece of the card above each hole that is a property of the object. (See the example on the next page.) When all the cards are finished, stack them and push a wire through a given hole to identify the objects that have that property.

4. Have students investigate ways that flow charts and keysort cards are used to classify and retrieve information in business and industry.

FLOW CHART SYSTEM


All Objects
Paper
wax paper
tissue paper
writing paper
Has Lines
writing paper
No Lines
tissue paper
wax paper
Wax
wax paper
No Wax
tissue paper
Not Paper
wood
straw
foil
nail
cloth
wire
paperclip
Metal
foil
nail
wire
paperclip
No Metal
wood
straw
cloth
Flat
foil
Not Flat
nail
wire
paperclip
Bends Easily
wire
paperclip
Does Not Bend Easily
nail
Two Materials
insulated wire
Not Two Materials
paperclip
Round
straw
Not Round
wood
cloth
Hard
wood
Not Hard
cloth

KEYSORT SYSTEM



Instructional Objective

Given a material, list objects made from it and identify the properties that make it suitable for its specific uses.

Concepts

Property
Matter
Material

Materials needed:

an object collection
references

Learning activities:

1. Have students assemble a collection of objects made from many different materials. Let individuals or small groups name the objects that contain a specific material and identify properties of the material that make it suitable for its use. Let them list objects other than those in the class collection. Have students make charts like the one below.

MATERIAL	OBJECT	PROPERTY
glass	mirror	transparent, hard, smooth
	tumbler	hard, smooth, can be shaped
	windows	transparent, hard, can be shaped
wood	chair	hold its shape well
	handle	strong, can be cut drilled, shaped

2. Introduce the concepts of "matter" and "material." Define them.

3. Have students add many commercial products to their collection. Have them investigate the ingredients of prepared foods and drugs and try to identify the purpose of each ingredient in the product.

Instructional Objective	Concepts
Given some indicators, identify their interactions with specific materials.	Indicator Acid Base

Materials needed:

bromothymol blue
litmus paper, red and blue
tincture of iodine
lemon juice
potato
baking soda or sal soda
plastic tumblers
medicine droppers

Learning activities:

1. Have students explore the interaction of baking soda and vinegar with bromothymol blue. Instruct them to place a drop of vinegar into BTB and observe the interaction. Let them drop some baking soda solution into the same container and observe what happens. Let them drop other liquids into the BTB and make a chart showing which materials turned the BTB yellow; which materials would turn yellow BTB back to blue; and which materials produced no change at all.

   Introduce the concept of "indicator." Explain that BTB indicates or reveals one property of a substance. Have students explore other properties of the materials that turn the BTB yellow and see if there is a common property among them. Explain that BTB is an acid-base indicator and that substances that turn the BTB from blue to yellow are acids and those that turn BTB from yellow to blue are bases.

2. Let students explore the interaction of known acids and bases with litmus paper. After they have learned which color paper indicates acid and which indicates a base, have them test all kinds of materials from home - cosmetics, shampoo, beverages, soaps, and detergents. Some of these products are advertised as being non-alkaline or anti-acid. Find out what these terms mean. Test the products to see if the claims are valid.

   Let interested students use references to investigate the use of Ph paper.

3. Have students explore the interaction of vinegar and baking soda. Ask, "Can baking soda be considered an acid indicator? Do other acids react this way to baking soda?"

Have students explore the interaction of tincture of iodine with a potato. Let them test bread, flour, and different kinds of fruit and vegetables with iodine. Ask "What does iodine indicate the presence of? (starch) What other substances have this reaction to iodine?"

Instructional Objective	Concept
Given white powders, use indicators to identify them.	Indicator

Materials needed:

salt
baking soda
vinegar
water
heat source
sugar
starch (corn or laundry)
plaster of paris
tincture of iodine (diluted)

Learning activity:

Give each student a set of the five powders. Instruct them to observe each powder as it interacts with heat, vinegar, water, and iodine. Have them make a record of their observations.

Give each student a mixture of two or more powders. Instruct students to try to identify the powders in the mixture by using heat, vinegar, water, iodine as indicated.

Instructional Objective	Concept
Given references and other resources, identify ways indicators are used in environmental control and other human activity.	Indicator

Materials needed:

reference books

Learning activity:

# Have children use reference books and other resources to find out how indicators are used in various occupations and industries. Swimming pool maintenance, chemical laboratories, environmental control, water works, the Food and Drug Administration, and the mining industry use indicators.

Drug stores carry test products of various kinds. Have a student interview a chemist, a pharmacist, and a laboratory technician to learn how indicators are used in their work.

Instructional Objective

Given appropriate materials, identify the variables that affect the phases of matter.

Concepts

Phases of matter
Solid, liquid, gas

Materials needed:

- paraffin
- candles
- ice
- heat source
- stick deodorant
- camphor
- moth balls or moth crystals
- list of materials

Learning activities:

1. Provide students with a list of materials. Have them classify the materials as solids, liquids, or gas. Let the students identify the materials that can exist in all three phases. Discuss and illustrate each phase with an example.

2. Have students do some of the following and describe the changes that take place.
   A. Melt paraffin. Allow it to cool.
   B. Burn a candle. Collect carbon and water from the flame on a piece of glass.
   C. Place an ice and water mixture in a can and observe the outside of the can. Add salt to the mixture and observe.
   D. Wipe a wet sponge on the chalkboard. Fan the wet area.
   E. Observe a piece of stick deodorant, camphor, or moth crystals over a period of time.

# 3. Ask the students to identify the conditions (variables) that affected the phases of materials in the investigations above. Ask, "How does heating affect a substance? What happens when a gas or liquid is cooled? How does fanning affect a liquid? Did all the materials go through the liquid phase? In what ways are commercial products protected from drying out or melting?"

Instructional Objective

Given appropriate materials, demonstrate a physical and chemical change.

Concepts

Physical change
Chemical change

Materials needed:

- paper
- matches
- ice cubes
- balloons
- pencils
- aluminum pan
- clay

Learning activities:

1. Distribute objects (clay, ice cubes, balloons, etc.) to children. Instruct them to change the objects in some way. Discuss what they did and how the object changed. Introduce the concept of physical change.

2. Burn a piece of paper in an alumiunum pan. Have students compare properties of the residue to the properties of the paper before it was burned.

   Burn a candle. Have a student hold a mirror over the burning candle. Discuss the students' observations. Introduce concept of chemical change.

Instructional Objective	Concepts
Given changes in matter, classify them as physical or chemical.	Physical change Chemical change Conservation

Materials needed:

- cookies
- vinegar
- baking soda
- rusty nail
- matches

Learning activities:

1. Demonstrate physical and chemical changes to the class. Show them objects that have undergone change. Instruct students to complete a chart classifying the changes as physical or chemical giving reasons for their classification.

EXAMPLES	TYPE OF CHANGE	REASON
crumbling cookie		
baking soda in vinegar		
sugar in water		
striking a match		
freezing water		
burning sugar		
evaporating water		
baking cake		
souring milk		
rusting nail		

2. Ask students what properties of matter can be used to classify a change as chemical or physical.

3. Introduce the concept of conservation. Discuss with the children how matter was changed in the preceding activity. Was it destroyed? Did it change form?

Instructional Objective	Concepts
Given various materials, classify them as elements, compounds, and mixtures	Elements Compounds Mixture Substance

Materials needed:

a collection of materials including:

aluminum foil
coal
graphite
lead
tin foil
reference books
charcoal
copper
iron
sulphur
zinc

Learning activities:

1. Have students make a class display of many different objects and materials. Include the materials listed above. Let students try to identify as many kinds of materials as they can.

2. Have students use reference books to prepare a list of elements. Make a display or duplicate a list for each student. Then have individuals or groups make charts of elements using examples from the class collection. Let them make a chart of compounds and another of mixtures. Try to include solids.

   Let students look up "element," "compound," and "mixture" and define them.

   Have students find the list of ingredients on commercial products and classify them as elementary compounds and mixtures.

Instructional Objective	Concepts
Given appropriate materials, illustrate the presence of elements in a compound.	Element Compound

Materials needed:

sugar
pan or test tube
spoon
copper chloride
aluminum foil
candle
a piece of glass
hot plate or gas burner
water

Learning activities:

NOTE: The following activities should be demonstrated by the teacher or be very carefully supervised.

1. Heat sugar in a pan on a hot plate or over a gas burner in a test tube. When the sugar begins to decompose, hold a piece of glass above it. Ask, "What is forming on the glass?" (water), "What is remaining in the pan (or test tube)?" (carbon), "What type of substance is sugar?" (compound), "What type of substance is water?" (compound), "What type of substance is carbon?" (element).

Have students use a reference book to find out what elements compose water. Have them look up "electrolysis" in an encyclopedia to find out how water can be decomposed into its elements. The teacher may remind the students that sugar is a carbohydrate and ask what elements are suggested by that name.

2. Hold a spoon over a burning candle. Ask, "What is forming on the spoon?" (carbon). "From where did it come?" What type of substance is the candle wax?" "What type of substance is carbon?"

3. Have students dissolve copper chloride in water and place a small piece of aluminum foil into it. Have them describe what happens to the aluminum. Let them filter the solution and try to identify the material in the filter paper (copper).

Instructional Objective	Concepts
Given a chemical formula of a compound, name the elements of which the compound is composed.	Element Compound

Materials needed:

a table of elements with symbols
reference books

Learning activities:

1. Have students use reference books to find the chemical symbols of some of the most common elements.

2. Give them the formulas for some common compounds and have them write the names of the elements of which the compounds are composed.

Some common elements and their symbols are given below:

ELEMENT	SYMBOL	ELEMENT	SYMBOL
Calcium	Ca	Iron	Fe
Carbon	C	Nitrogen	N
Chlorine	Cl	Oxygen	O
Copper	Cu	Sodium	Na
Hydrogen	H	Sulphur	S

Some examples of compounds and their formulas are given on the following page. Let students fill in the third column.

COMPOUND	FORMULA	ELEMENTS
carbon dioxide	CO_2	carbon, oxygen
calcium hydroxide	$Ca(OH)_2$	calcium, oxygen, hydrogen
baking soda, sodium bicarbonate	$NaHCO_2$	
washing soda, sodium carbonate	Na_2CO_3	
table salt, sodium chloride	$NaCl$	
iron rust, iron oxide	Fe_2O_3	
water	H_2O	

Instructional Objective

Given various materials, mix them and describe the properties of the mixtures.

Concepts

Solution
Settling suspension
Colloidal suspension

Materials needed:

salt
sugar
flour
soil
oil
vinegar
plastic tumblers, vials, or other containers
food coloring
milk
alcohol
water

Learning activity:

Provide the materials listed above and instruct the students to place a small amount of each substance in some water and observe what happens.

Ask the students to classify the mixtures into groups according to their appearance.

Introduce the words "clear" and "cloudy". Have students identify which materials formed a clear mixture and which formed a cloudy mixture.

Introduce the concepts "solution" and "suspension". The teacher may wish to do this with 2-4 students, while they are exploring with the materials. An alternative would be for the teacher to demonstrate with the same materials the next science period, discuss what happened and introduce the words.

Show the class (or small groups) a settling and non-settling suspension. Let them state the similarities and differences of each. Introduce the words "settling" and "non-settling." Use the term "colloid" or "colloidal suspension" for a non-settling suspension.

Ask the students how they might distinguish a solution from a suspension and a settling suspension from a colloid. Let them try to wrtie or state orally an operational definition of each.

Save these liquid mixtures so they may be used with the next objective.

Instructional Objective	Concepts
Given liquid mixtures, classify them as solutions, colloidal suspensions, or settling suspensions and give reasons for the classification.	Solution Settling suspension Colloidal suspension

Materials needed:

- mixtures from preceding activity
- tea
- liquid starch
- plastic vials
- white vinegar
- sand
- food coloring
- milk

Learning activities:

1. Display vials of liquid mixtures in an interest center. The mixtures may include tap water, colored water, salt water, milk, milk and water, soil and water, and and water, vinegar, tea, and liquid starch.

   Write the words solution, colloidal suspension, and settling suspension on cards. Have students classify the vials and use the cards to identify their classifications.

   Have students record their observations on a data sheet like the one below.

MIXTURE	KIND OF MIXTURE	MY EVIDENCE
vinegar	solution	clear
milk	colloidal suspension	cloudy; does not settle
soil & water	settling solution	settles after standing

# 2. Have students bring in a list of commerical products that are liquid mixtures, classify them, and add them to the chart above.

Instructional Objective

Given appropriate materials, prepare solutions and identify the variables that affect their concentrations.

Concepts

Solvent
Solute
Saturated solution

Materials needed:

sugar
water
test tubes
test tube clamps
sodium thiosulfate
light source
stirring rod
heat source

Learning activities:

CAUTION: When heating liquid mixtures in a test tube, move the test tube in a circular motion through the flame to prevent spattering. Marble chips placed in the test tubes help control spattering.

1. Have students use the following procedures to explore variables that affect the concentration of solutions.

   Place a few grains of sugar into a test tube with about 25 milligrams of water. Observe. Does it dissolve? Shake or stir the water and observe. Add more sugar and stir. Continue to add sugar until no more dissolves. Add more water. Heat the test tube. Add more sugar.

   Have students list the variables that affected the amount of sugar that would dissolve. Typical responses will be: the amount of sugar used; the amount of water used; the stirring and shaking; and the temperature of the water. Use the words solvent and solute when referring to the sugar and water. Introduce the concept of saturated solution. Define it. Discuss the affect of temperature on the concentration of solute in a saturated solution.

2. Have students prepare a supersaturated solution of sodium thiosulfate as follows:

   Place four milligrams of sodium thiosulfate into a test tube. Use micro test tubes if available. Add a few drops of water and heat carefully until the crystals dissolve. Place the test tube in a beaker and allow it to cool to room temperature. Keep it still. Add one crystal of sodium thiosulfate. Hold the tube up to a strong light and observe. Repeat the procedure but instead of adding a crystal, try tapping the bottom of the tube to force the solute to crystallize.

   Discuss the variables that affect the concentration of solute in a supersaturated solution. Also, compare the stability of saturated and supersaturated solutions.

3. Have students examine labels of commercial products that are solutions and record the percents of concentrations of the ingredients listed.

Instructional Objective

Given a liquid mixture, separate it into its parts.

Concepts

Evaporation
Filtration
Decanting

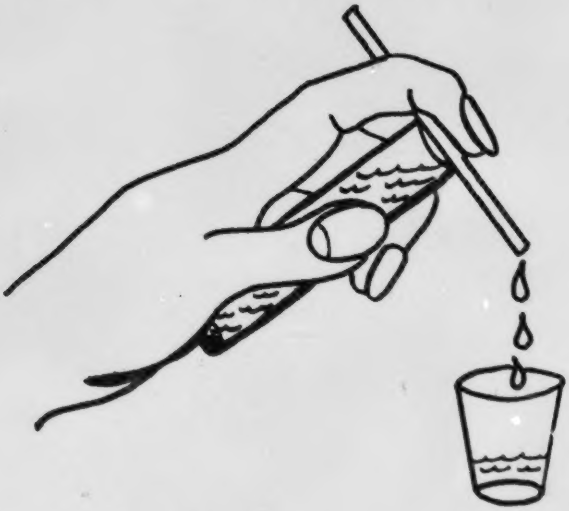
Materials needed:

plastic vials with caps
platform balance
sandy soil
graduated cylinder
spoon
glass stirring rods
aluminum evaporating pans
heat source
plastic funnels
filter paper
filter stands
masking tape or self-adhesive labels
test tube clamps

Learning activities:

1. Provide each student with a plastic vial. Have students label their vials and place in them about five grams of salt, ten grams of soil, and 20-30 milligrams of water. Have them shake the vials vigorously for about 3 minutes and let them stand over night. Have students work in pairs and separate the materials in the following ways:

    a. Decanting - Place a glass stirring rod over the top of a vial and pour the liquid slowly into a tumbler or some other container.



b. Filter - Prepare a pice of filter paper by folding it into quarters. Open it into the shape of a cone and place it into a funnel. Moisten the filter paper with water.

c. Evaporation - Have students filter the liquid through filter paper into an aluminum pan. Instruct them to hold the pan over a heat source and heat gently until about one-half of the liquid is evaporated. Store pans where they will not be disturbed. Allow them to stand until the liquid is completely evaporated. Have students report what they observed and what they think happened.

d. Filtration - Instruct the teams of students to again shake the mixture in their other vial. Filter this mixture immediately. Have students identify which materials are on the filter paper and which materials are in the pan.

2. Discuss the foregoing procedures to reinforce the names of the processes used. Refer to pictures, experience charts, or demonstrate each process. An interesting approach is to write the words "settling," "decanting," filtering," and "evaporating" on cards and let students match them with pictures or actual equipment that illustrates each process.

Instructional Objective	Concepts
Given appropriate materials, construct atomic and molecular models.	Atom Molecule

Materials needed:

toothpicks
clay
styrofoam balls
reference books
wire

Learning activities:

1. Instruct children to use reference books and materials listed above to construct some of the simpler atoms, (hydrogen, helium, carbon, oxygen, and nitrogen). Some students may wish to draw pictures instead of constructing a model.

2. Have children draw pictures or make models of molecules of selected compounds (water, hydrogen peroxide, carbon dioxide).

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

734	Bottled Candle Mystery
806	Combustion: An Introduction to Chemical Change
2463	Evidence for Molecules and Atoms
2402	Explaining Matter: Chemical Change
2305	Explaining Matter: Molecules in Matter
766	How Materials Are Alike and Different
1731	Simple Changes in Matter
728	The Speed of Chemical Change
927	Things Change: Solids, Liquids and Gases

Filmstrips

6118	Changes All Around Us
7459	Fundamentals of Science: Matter and Molecules
6120	How Things in the World Change
7359	Molecules
6748	World's Matter Supply

SOUND

Background

Sound is a very important part of our environment. People recognize many objects by the sounds they make. We depend on sounds for communication with others, for warnings, and for pleasure. Sounds such as music and laughter may be very pleasant. Sounds such as the noise of a jet aircraft or an air hammer may be a source of annoyance, discomfort, and even danger. Sounds that are too loud produce sensory overload and may cause permanent damage to the ear. Noise pollution is a serious problem in urban living.

Vibration and Sound. Although we may think of sound as something we hear, scientists define sound as a form of energy produced by vibrating objects. Vibrations are repeating back and forth or up and down motions. Vibrations are not only heard, they may also be seen and felt. As objects vibrate they make the surrounding air vibrate. The vibrations travel through the air and we hear these as sounds.

Properties of Sounds. Sounds have different properties which enable us to distinguish one sound from another. Sounds vary in pitch, intensity, and timbre.

Pitch. The pitch of a sound is determined by how fast the object vibrates. The number of vibrations per second is called the vibrating frequency. The higher the frequency, the higher the pitch. Most children can learn to tell whether one tone is higher or lower than another tone.

People with normal hearing can hear frequencies between 20 and 20,000 vibrations per second. Some animals can hear sounds above or below this range. Dogs and bats can hear sounds much higher than those heard by people.

Intensity. The intensity of a sound is the amount of energy applied to an object to cause it to vibrate. The higher the intensity, the louder the sound produced. Intensity is one of four variables that determine the loudness of a sound. The others are: the distance of the object from the ear; the density of the surrounding medium; and the area of the vibrating object.

Children often have difficulty in distinguishing the difference between pitch and loudness. The terms "high" and "low" are often confused with "loud" and "soft." Much practice is often needed to help children develop the concepts and vocabulary related to pitch and loudness.

Resonance. Resonance occurs when a small force used to vibrate an object is repeated at the same frequency as the natural frequency of the vibrating object. This produces large vibrations and increases the loudness of the sound.

The loudness of musical instruments is increased by resonance. On a stringed instrument, such as a violin, resonance is produced by the hollow chamber under the strings. This chamber is called the resonance box.

Timbre. Timbre is the quality of a musical sound that distinguishes a tone produced by one instrument from a tone produced by another instrument. An object such as a string, a column of air, or the head of a drum may vibrate as a whole and in parts at the same time. When it vibrates as a whole it produces its fundamental tone. At the same time, it may vibrate in halves, thirds, or fourths, producing what are called overtones. The number and strength of the overtones determine the distinguishing quality or timbre of the tone.

Echo. An echo is the repetition of a sound bouncing off an object. Sound energy can be reflected off materials that have a different density than the surrounding air. If we stand far enough away from the reflecting surface we can hear the original sound and its echo.

Transmission of Sound. Sound travels from the vibrating object, through various materials called media. Air is the most important medium to people because most of the sounds we hear come to us through air. Sound can also be transmitted through water and through solids such as wood or metal. Sound travels at a speed of 1,100 feet (1,400 meters) per second through water, and 16,000 feet (4,800 meters) per second through steel.

Sounds may be reflected and absorbed. Hard surfaces reflect sounds. Soft surfaces absorb and deaden sounds. Soft material such as carpets and drapes are used in rooms to control and deaden sounds.

Sound System. A vibrating object, the transmitting medium, and the sound receiver may be thought of as a sound system. Each of the parts of a sound system may be referred to as a subsystem. Energy is transferred from the energy source to the vibrating object, through the medium which transmits it to the receiver. The receiver may be the ear of the listener, a tape recorder, or another object which is set in motion by the vibration.

Sound Waves. Sound travels through a medium in waves. The vibrating object produces a repeating pattern of compressions and rarefactions that move outward from the source of vibration. Sound waves are longitudinal waves. These can best be illustrated by compressing some of the coils of a long spring, releasing them, and observing the pattern that moves along the spring.

Rationale

This unit, "Sound", is designed to help children: (1) produce, identify, and describe sounds; (2) identify and describe the properties of sounds; (3) perceive the relationships between the structure of objects and the characteristic sound they produce; (4) identify media that transmit sounds; and (5) begin to use the wave model to explain how sounds are produced and transmitted.

The sounds around us are many and varied. Children are intrigued by sounds and by instruments that produce them. A study of sound offers many opportunities for students to investigate cause and effect relationships.

Glossary of Concepts

Sound	A form of energy caused by vibrating objects.
Vibration	A repeating back and forth or up and down motion.
Pitch	The highness or lowness of a sound.
Frequency	The number of vibrations per second.
Variable	An object or condition that changes and affects the outcome of an event.
Intensity	The amount of energy transferred through a vibrating object.
Loudness	The volume of sound heard; how loud or soft a sound is perceived.
Resonance	Increased loudness caused by the build-up of a repeated low intensity force.
Timbre	The distinctive quality of a sound.
Transmission	The movement of sound energy through materials.
Medium	A material through which sound energy moves.
Acoustical quality	The ability of a material to either reflect or absorb sound; the way a material interacts with sound.
Reflection	The bounce of sound.
Absorption	The softening of sound by a material.
Echo	The repetition of a sound that bounces off an object.
Sound system	A group of objects and materials that produce, transmit, and receive sounds.
Sound wave	A pattern of motion within a medium caused by a vibrating object.

Investigations

Instructional Objective	Concept
Given a variety of sounds, identify the objects making the sounds.	Sound

Materials needed:

cassette tape recorder
objects for making sounds: whistles, bottles, bells, paper, cans, pencils

Learning activities:

1. Have students sit quietly for two minutes and name the sounds they hear. Make the distinction between the words that name objects and the words that name sounds. Record the information on a chart like the one below.

Object	Sound
bell	ring
pencil	tap
whistle	whistle
shaker	rattle

2. Let students provide "mystery sounds" for other to identify.

# 3. Have students make up categories of human activities and classify the sounds they have listed. Add other categories as needed.

Working Sounds	Playing Sounds	Eating Sounds
drill hammer	children laughing	wrapper rattling
bus passing	ball bouncing	fork hitting tray
garbage truck	skates rolling	

Instructional Objective | Concept

Given a variety of sound makers, identify the vibrating part.

Vibration

Materials needed:

sound makers: rulers, twine, bottles, rubber bands, tuning fork, others
musical instruments

Learning activities:

1. Place a number of sound makers around the room in learning stations. Let students circulate through the learning stations and make many kinds of sounds. Discuss the meaning of "vibration." Let students hear, see, and feel the vibrating objects. Have them identify the vibrating part of each object.

   Demonstrate the proper use of the tuning fork before letting students use it. Strike it on a rubber heel of a shoe or on the leg above the knee since hard surfaces will damage the metal and may alter the pitch of the tuning fork. Place the tip of a vibrating tuning fork in water to demonstrate its energy as it splashes the water.

2. Demonstrate or have someone else demonstrate how sounds are made on some musical instruments. Have students identify the vibrating part of each instrument. Have them record the information on a chart like the one below. Include information gathered in the previous activity.

Object or Instrument	How the Sound is Made	Vibrating Part
whistle	blowing	air
bell	striking	metal bell
glass tumbler	striking	glass sides
recorder	blowing	air
piano	striking with hammer	strings

Instructional Objective	Concept
Given two tones on a musical instrument, distinguish differences in pitch.	Pitch

Materials needed:

a musical instrument such as a piano, a recorder, or melody bells

Learning activity:

Play two different tones on a musical instrument. Ask the students if the sounds were alike or different. Play two tones that are alike and ask again. Give five examples of two tones each and have students write "a" if the two tones are alike and "d" if they are different. Provide the correct answer after each example. Give five more examples but provide the answers after the five examples are completed.

Introduce the word "pitch." Illustrate high and low pitches on the instrument. Play two tones on the instrument that have different pitch and ask the students to state whether the second tone is higher or lower than the first. Give them several examples and vary the interval between the two tones. Give five examples and have students record their responses on paper. Record examples on tape for individual and small group practice. Seek the help of the music teacher if necessary.

Instructional Objective	Concepts
Given appropriate materials, identify the variables that affect the pitch of a tone.	Pitch Frequency Variable

Materials needed:

rulers
rubber bands of different thicknesses
pop bottles and water
glass tumbler and water
drinking straws and scissors
wood, nails, hammer

Learning activities:

1. Use the materials above in learning stations. Let students explore ways to vary the pitch of the sound produced with each material.

2. Demonstrate or have students demonstrate how sounds of different pitches are made with a ruler. Discuss the relationship of the vibrating part of the ruler to the pitch of the tone produced.

   Have students compare the speed of a vibrating meter stick to that of a ruler. Introduce the concept of "frequency" and define it. Discuss the relationship of the vibrating frequency to the pitch of the sound produced.

   Use a pendulum or weighted spring to count the number of vibrations per minute. Show the students the number on a tuning fork. Tell them that the tuning fork vibrates that many times per second. Have students use reference books to find the range of frequencies heard by different animals.

3. Provide students with the following situations and have them predict whether the resulting pitch will be higher or lower than the original tone. Let them test their predictions by experimentation.

   a. Blow into a pop bottle. Add water and blow again.

   b. Strike a glass tumbler with a pencil. Add water and strike again.

   c. Stretch a rubber band between your fingers and pluck it. Stretch it more tightly and pluck it.

   d. Stretch a piece of twine between two chair legs and pluck it. Press it tightly in the middle and pluck one side of it.

   e. Drive a long nail into a piece of wood until it is tight. Pluck the head of it with your thumb. Drive it in farther and pluck it again.

   f. Cut the tip of a drinking straw into a "V" shape so the tip of the straw comes to a point. Press the two pieces together with your teeth. Blow gently to make the straw hum. Cut 4 centimeters off the end of the straw and blow again.

4. Demonstrate, or invite someone else to demonstrate, the pitch range of one or more musical instruments, how different pitches are produced on the instrument, and how the instrument is tuned. Let students see the strings of a piano and identify the variables that determine the pitch of the strings.

Instructional Objective	Concepts
Given two sounds, distinguish differences in intensity.	Intensity Loudness

Materials needed:

sound makers
musical instruments

Learning activities:

1. Have students clap their hands softly then loudly. Have two people clap their hands then let everyone clap their hands. What differences are observed? What made the difference? Have students make loud and soft sounds with sound makers and instruments. Ask them what they did to make a loud sound and a soft sound.

   Introduce the concept of "intensity" and define it. Discuss how it affects the loudness of a sound.

2. Play two tones of the same pitch on a musical instrument. Have students tell whether the second sound is louder or softer than the first. Give many examples using different instruments or sound makers.

Instructional Objective	Concepts
Given appropriate materials, identify the variables that affect the loudness of a sound.	Intensity Loudness Variable Resonance

Materials needed:

tuning fork
rubber bands
small cardboard or wooden boxes
reference materials

Learning activities:

1. Let students explore with different sound makers to try to find variables other than intensity that affect loudness. Make the following suggestions if necessary.

a. Listen to sounds from varying distances.

b. Rank sound makers and instruments in order of loudness from softest to loudest. Try to identify variables responsible for loud sounds and soft sounds. Does the size of the instrument make a difference?

c. Make sounds with rubber bands. Place them around a cardboard or wooden box. Describe the difference the box makes.

d. Strike a tuning fork. Place the lower end on a desk. Place your ear on the desk.

e. Observe stringed instruments and find out how the sounds of the vibrating strings are made louder.

2. Introduce the concept of resonance. Let students use reference materials to find information about resonance and how it can be used to make sounds louder.

Instructional Objective	Concept
Given appropriate materials, compare the quality of sound produced by different musical instruments.	Timbre

Materials needed:

record player
phonograph records
musical instruments
sound makers

Learning activities:

1. Play phonograph records and have students identify the instruments they hear. Have someone play sounds of the same pitch on different instruments and ask students to tell how the sounds are different and how they are alike. Introduce and define the concept of "timbre." Have students try to describe the timbre of different instruments.

2. Have students use reference books and other media to find information on timbre, harmonics, and overtones. Have the music teacher demonstrate these to the students. If possible visit a place where there is an organ and have someone demonstrate how the organ produces sounds of different quality. Have students listen to a tuning fork on a bell and see if they can hear more than one tone. (The low tone is the fundamental tone and the high tone is an overtone.)

Instructional Objective	Concept
Given appropriate materials, have students make musical instruments.	Vibration Pitch Timbre

Materials needed:

- reference books
- bottles or test tubes
- fishing line
- cardboard boxes
- wood
- wood tools
- screw eyes and other hardware

Learning activity:

# Have students make simple musical instruments. Let them use many references to find information on making home-made musical instruments. One valuable source is "The Music Instrument Recipe Book" (see bibliography). Provide or have students bring in the necessary materials to make the instruments. Seek the help of the art teacher. A public demonstration and display of the instruments to parents, school and/or community would make an excellent culminating activity for this unit.

Use this activity to review and reinforce concepts taught in the unit. Emphasize especially the concepts of vibration, pitch, and timbre.

Instructional Objective	Concept
Given a variety of materials, illustrate and compare their ability to transmit sound.	Transmission Medium

Materials needed:

- tuning fork
- plastic bag or an aquarium
- paper cups or plastic foam cups
- twine
- yarn
- wire
- reference materials

Learning activities:

1. Have students place their ears on their desks while listening to sounds. Let them tap the sides or top of the desk and the floor. Place the base of a vibrating tuning fork on the top of the desk. Let them listen to sounds through cardboard tubes, a garden hose, an aquarium filled with water, walls, a piece of wood and any other available object. Have them compare the ability of the various materials to transmit

sound. Introduce the concept of "medium" and define it.

2. Have students make telephones from paper or plastic cups and yarn, twine, thread, or wire. Let them experiment to find which materials work best. It may help to rub wax on the thread and twine.

3. Have students measure the distance they can hear a clock ticking. Then have them use tubes, a garden hose, or other objects, and measure the distances they can hear the clock through them.

#4. Have students use reference books to find information on the following related topics.
   a. The history of communication
   b. Voice tubes
   c. Telegraph
   d. Telephone
   e. Radio and television
   f. Underwater cables
   g. Coaxial cables
   h. Sonar
   i. Communication satellites
   j. Careers in communication

Instructional Objective	Concepts
Given various materials, compare their acoustical quality.	Acoustical quality Reflection Absorption Echo

Materials needed:

- two cardboard cartons
- aluminum foil
- cloth
- alarm clock
- whistle
- drum

Learning activities:

1. Have students cover the inside of one cardboard carton with aluminum foil and another with cloth or some other soft material. Place the boxes at one end of the room with the open end toward the students. Put a ringing alarm clock or an electric door bell inside the box with the foil and place it inside the other box. Have students compare the sound of the bell in each box. Ask, "Which one was louder?" Introduce the concept of "acoustical quality." Discuss the acoustical quality of the material in each box. Discuss the ability of materials to reflect and absorb sounds.

2. Visit various locations in and around the school. Have students compare the acoustical quality of various rooms. corridors, and other locations.

3. Take students outdoors where there is a large wall and considerable open space beyond it. Have students stand 40 to 50 meters from the wall while one child moves away from the wall blowing a whistle or striking a drum. Have students tell when they begin to hear two distinct sounds, an echo. Have them measure the distance from the object to the wall where the echo was first heard.

# 4. Have students use reference materials to find information about the following.
   a. Acoustics
   b. Methods of sound control
   c. Bats and how they navigate
   d. Sonar
   e. Radar
   f. Parabolic microphones

Instructional Objective	Concept
Given a sound system, identify its parts.	Sound system

Materials needed:

sound makers

Learning activity:

As someone makes a sound, have students identify the force that causes the vibration, the vibrating object, the transmitting medium, and the sound system. Introduce the concept of "Sound receiver." Have students give other examples of sound systems and name their parts.

Instructional Objective	Concept
Given appropriate materials, demonstrate how sound travels in waves.	Sound wave

Materials needed:

slinky toy
pan of water

Learning activity:

Have students place the tip of a finger into a pan of water and observe the waves. Have students fasten one end of a rope, flip the other end and observe the motion of the rope. Introduce the concept of "wave." Stretch out a slinky toy between two students. Have them keep it off the floor and get it as still as possible. Compress three or four coils of the slinky, release it and observe its motion. Explain that the type of wave in the slinky is the type of wave that best illustrates sound waves.

Instructional Objective	Concept
Given reference materials and resource people, report on careers in sound.	Careers

Materials needed:

reference books
resource people

Learning activities:

# 1. Invite resource people to discuss how they use sound in their work.

# 2. Have children use reference books to find and report on careers in the following related areas.
   a. Radio and television broadcasting
   b. Acoustical engineering
   c. Phonograph and tape recording
   d. Ultrasonic
   e. Sonar
   f. Sound pollution control
   g. Musical instruments

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For Teachers

Elementary Science Study. Whistles and Strings. Webster McGraw-Hill, 1971.

Elementary Science Study. Musical Instruments Recipe Book. Webster McGraw-Hill, 1971.

Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

791	Sound About
894	The Science of Musical Sounds
1700	Nature of Sound
147	Vibrations
1695	What Is Sound

Filmstrips

6687	The Cause and Nature of Sound (Heat, Light, and Sound)
7455	Fundamentals of Science - Sound
7458	Fundamentals of Science - Sounds We Hear
6688	How Sound Travels (Heat, Light, and Sound)
7753	An Introduction to Sound (Introduction to Matter and Energy)
8743	The Science of Sound

Materials listed in "Media Approved for Purchase" - 1975

Charts

A.J. Nystrom Company

Davis-Smith Science Charts

Sound and Its Characteristics
Hearing and Music

Tapes

Imperial Productions, Inc.

Sound - The Invisible Wonder

HEAT

Background

Evidence of Heat Energy. Heat is a form of energy. Evidence of heat energy is perceived as one feels a warm object through his skin. One can also observe effects of heat as objects change size or materials change from solid to a liquid or from liquid to gas.

Producing Heat. Heat is produced by chemical actions, friction, electricity, and nuclear (atomic) energy. The sun is our most important source of heat energy. The earth would be cold and lifeless without it. The sun also stores energy in the earth in the form of wood, coal, oil, and natural gas. When these fuels burn they combine with the oxygen of the air and produce other compounds. These chemical reactions produce heat. Friction is usually an unwanted source of heat. Lubricants and bearings are used to reduce friction in machines. However, friction is useful to ignite the matches we use so frequently. Electricity is used as an important source of heat in many of the appliances we use. Although nuclear energy in the form of atomic weapons is a tremendous threat to life on earth, it also has great promise as an important source of electrical energy.

The earth itself is an important source of heat. The earth, warmed by the sun, in turn warms the air to comfortable levels. The interior of the earth is also very hot. This is another source of energy that people have tapped for their use.

Energy Transfer. Heat can be transferred into other forms of energy. Heat produced by burning fuels can be used to move automobiles, trains, airplanes, and ships. Thus, chemical energy is changed into heat and heat is changed into mechanical energy.

Heat energy is transferred from a warm object to a cooler object. The objects involved in such a transfer of energy may be thought of as being part of a heat system; one object is the heat source and the other is the receiver. The evidence of the energy transfer is an increase in temperature, the change of size, the change of the state of the material, or as in the case of a chemical change, the change of the composition of the material. Electricity and burning can produce light which is another evidence of energy transfer.

When two materials of different temperature are in contact with each other heat is transferred from the warmer material to the cooler object. When both objects are the same temperature a condition of equilibrium is reached. When a thermometer is placed into warm water the heat energy is transferred from the warm water to the thermometer. When the thermometer is in equilibrium with the water, the liquid in the thermometer stops moving. Then the thermometer may be read.

When one object, or one material, transfers its energy to another object, or material, the first becomes cooler and the second becomes warmer.

Temperature and Heat. The temperature of an object is the measure of how hot or how cold it is regardless of its mass. Heat involves the passage of energy from one object to another. The amount of heat energy transferred from one object to another is determined by the mass of the receiving object, the amount of temperature increase, and its specific heat. (Specific heat, not dealt with in the student activities, is the amount of heat necessary to raise the temperature of one gram of a substance one degree Celsius.)

The temperature of two liters of water may be the same as the temperature of one liter of water. However, two liters of water would require twice as much heat energy to raise its temperature one degree than would one liter of water.

In the metric system, temperature is measured in degrees Celsius; heat is measured in calories. A calorie (lower case "c") is the amount of heat energy necessary to raise the temperature of one gram of water one degree Celsius. The unit used to measure energy in food is the Calorie (capital C) and is equal to 1,000 calories.

Heat Transmission. Heat is transmitted through materials and from one object to another by three processes;conduction, convection, and radiation. When one end of a metal object is heated, the heat is transmitted through the object by conduction so that the entire object becomes warmer.

When liquids and gases are warmed by a heat source the warmer, less dense fluid is pushed upward by the cooler fluid of greater density. A current of moving liquid or gas is produced. This is the process of convection.

Heat may also be transmitted through a gas or through empty space by radiation. When the energy is absorbed by some object, the object becomes warmer.

The Kinetic-Molecular Theory. The effect of heat on matter can be explained in terms of the kinetic-molecular theory. The theory is that: (1) matter is composed of molecules which are in constant motion; (2) the speed of the molecules is determined by temperature - the greater the temperature, the faster the molecules move; and (3) molecules have an attraction for each other.

Materials expand when heated because molecules are given greater kinetic energy as their speed increases. The molecules gain force in relation to the force of molecular attraction. The molecules move farther apart causing the material to take up more space.

Melting and boiling occur when the kinetic energy of the molecules becomes greater than the attracting forces of the molecules. In the case of liquid, the molecules have enough energy to move around one another. The molecules in a gas have enough energy to completely overcome the attracting force of the molecules and move away from the other molecules.

Dispersion of materials in liquids is explained by the movement of molecules in the liquid. Warm liquids disperse materials faster than will cooler liquids because the molecules in a warm liquid move faster than those in a cooler liquid.

Heat is transmitted by conduction because faster moving molecules collide with slower molecules causing them to speed up and become warmer.

Convection currents are produced in gases and liquids as heat causes molecules to move faster giving them energy to spread out more. The slower moving molecules are closer together making their collective volume heavier. Therefore, they sink and the warmer molecules are pushed upward.

Radiant energy is absorbed by objects. The increased energy results in faster moving molecules making them warmer.

Rationale

The unit Heat is designed to help students (1) perceive the effects of heat, (2) investigate different methods of producing and transferring heat, (3) distinguish the difference between heat and temperature, and (4) begin to use the molecular model to understand how heat affects the behavior of matter.

Heat as a form of energy is very much a part of the daily experiences of children. People not only use heat directly to provide a comfortable environment for themselves, but they also transfer heat into other forms of energy to produce light, motion, sound, and power. The study of heat and its effect on matter provide many stimulating opportunities for first hand involvement in science experiences. The high predictability of the behavior of heat makes it invaluable as a source for testing hypotheses through experimenting. The scientific phenomena related to heat have direct applications to other units of the science curriculum, especially Matter and Change, Air and Water, and Observing the Weather.

Glossary of Concepts

Temperature	How hot or how cold a material is; the speed of moving molecules.
Thermometer	An instrument used to measure temperature.
Heat	A form of radiant energy; the kinetic energy of moving molecules.
Calorie	The amount of heat needed to raise 1 gram of water 1° C.
Heat Source	An object or system that produces heat; an object that transfers heat to another object or system.

Heat Receiver	A system or subsystem that receives heat from another system.
Energy Transfer	The ability of matter to bring about changes in itself or in its environment.
Heat Equilibrium	Two or more objects becoming the same temperature after interacting with each other.
Expansion	The increase in the size of an object.
Contraction	The reduction of the size of an object.
Melting	Changing a solid substance to a liquid.
Boiling	Changing a liquid substance to a gas.
Condensing	Changing a gaseous substance to a liquid.
Freezing	Changing a liquid substance to a solid.
Dispersion	The spreading of a material throughout a liquid or other media.
Conduction	The process of transmitting heat energy through solids.
Convection	The process of transmitting heat in a vertical circling motion in liquids or gases.
Radiation	The process of transmitting energy in the form of waves which travel through space or matter.
Insulation	The process of preventing the flow of heat from one object to another; material used to insulate objects from heat or cold.
Kinetic Molecular Theory	The theory that molecules attract one another and are accelerated by increase in heat energy.

Investigations

Instructional Objective	Concept
Given objects of different temperatures, describe how they feel.	Temperature

Materials needed:

plastic tumblers
hot and cold tap water
ice cubes

Learning activity:

Provide containers of cold tap water, hot tap water, and ice water. Have students place their hands into each container and describe what they feel. Record the words they used to describe the different samples of water.

Have one group of students warm their hands in hot water and another group cool their hands in cold water. Instruct both groups to place their hands into water of room temperature. Ask, "How does the water feel?" Repeat the activity but reverse the procedure for each group. Ask, "Did the water at room temperature feel the same both times?"

During the discussion, ask, "What do we mean when we say an object is cool or cold, or warm or hot?" An object warmer than our skin feels warm while an object cooler than our skin feels cool. Coolness or warmness is relative to the temperature of our skin.

Instructional Objective	Concept
Given objects of different temperatures, rank them in order of their temperatures from coolest to warmest.	Temperature

Materials needed:

tumblers or metal cans
ice cubes
objects made of various materials
hot plate or other heat source

Learning activity:

Let students warm and cool objects by immersing them in water or placing them on ice cubes. Let them use radiators, if available, (and if they are safe) to warm objects. Ask them to place four or five objects in a row with the coolest object on the left and the warmest on the right. Let the objects stand for a while and try again. Ask, "How do the objects feel now? What caused the change?"

Instructional Objective	Concept
Given thermometers, read them correctly in degrees Celsius.	Thermometer

Materials needed:

thermometer - Celsius or dual scale
pictures of thermometers
water and other materials of different temperatures

Learning activities:

1. Provide students with pictures of thermometers or make a ditto sheet showing the scale of a thermometer. Give them experience in reading the temperature in both Fahrenheit and Celsius degrees. Do not be concerned with converting from one scale to another. Use the Celsius scale for most of your work in class.

2. Let students measure and record the temperature of many materials and objects.

Instructional Objective	Concepts
Given appropriate materials, determine the increase of heat energy when water is heated in a variety of ways.	Heat Calorie

Materials needed:

thermometer	metal objects
containers	tongs
water	goggles
candles	data sheet
balance	ring stand or other metal supports
	metal lids or asbestos pads

Learning activities:

1. Have students weigh 100 grams of water and pour into a metal container or glass beaker. Let them measure the temperature (degrees Celsius) of the water and record on a data sheet. Heat the water with one birthday candle; let the candle burn until it burns out completely. Measure the temperature of the water and record on the chart. Subtract the beginning temperature from the final temperature to get the amount of temperature increase. Multiply the temperature increase by the weight of the water to determine the number of calories of heat produced by the candle.

Heating Method	Weight of Water	Starting Temperature	Temperature after Heating	Increase in Temperature	Calories

2. Have students repeat the procedure but vary the method of heating, the volume of water, the length of time of heating, or the type of container. Have them estimate whether the number of calories will be greater or less than they were in the first activity, calculate the calories of heat increase, and check the accuracy of their estimate.

Instructional Objective

Given a variety of systems using heat energy, identify the energy source, energy receiver, and evidence of energy transfer.

Concepts

Heat Source
Heat Receiver
Energy Transfer

Materials needed:

examples and pictures of heat sources
data sheet

Learning activities:

# 1. Provide students with examples of objects being heated. Use actual materials, pictures, and verbal descriptions. Have students identify the heat source, the receiver, and the evidence of energy transfer. Encourage students to name fuels used to heat buildings. Have them use reference materials to find the sources of heat used in industries such as in steel mills, electric generating plants, and sugar refineries.

Discuss the concept of energy transfer. Help students trace the transfer of heat energy through a home heating system. Have the school engineer demonstrate and describe the school's heating system. Discuss the transfer of heat energy from fuel to water and steam to the radiators to air to people.

Have students record information on a data sheet such as the one below.

SYSTEMS USING HEAT ENERGY	ENERGY SOURCE	ENERGY RECEIVER	EVIDENCE OF ENERGY TRANSFER
cooking food	gas	food	gets tender
aquarium	electric coil in heater	water	gets warm gets warmer
bed	person	person	stays warm
furnace	gas (oil) or (coal)	air or water	air in house is warm

2. Have students give other examples of energy transfer by making energy chains. Some examples are as follows:

COAL ⟶ HEAT ⟶ STEAM ⟶ ELECTRICITY ⟶ LIGHT

GASOLINE ⟶ HEAT ⟶ PRESSURE ⟶ MOTION

FOOD ⟶ HEAT ⟶ MUSCLE ⟶ MOTION

Have students illustrate these with pictures and display them on the bulletin board.

Instructional Objective	Concept
Given a variety of objects, heat them in various ways.	Heat Source

Materials needed:

objects of various materials - wood, plastic, cloth, metal, etc.
balloons or rubber bands
paper clips
ice
warm water
metal containers and/or glass beakers
washers, nails, or other metal objects
heat source - hot plate, candle, gas burner, canned heat

Learning activities:

1. Provide the materials above and instruct students to warm the objects in as many ways as they can think of. They may hold objects against their bodies, rub them in their hands, or rub one object against another. They may discover that a balloon or rubber band becomes warm when stretched or that a paper clip becomes warm by bending it repeatedly.

2. Brainstorm with students to see how many ways they can suggest to heat water in a container. Have them heat the water in many different ways.

   Methods they may suggest are: (1) heat directly with heat source; (2) hold metal washers with tongs, heat in a flame and drop them into water; (3) place a small container of water in a larger container of hot water.

# 3. Ask the students to continue thinking about ways that objects can be heated. Ask, "What appliances or tools do you know of that get warm when used?" Make a class list and place it on the bulletin board. They may wish to draw pictures to illustrate these.

Instructional Objective	Concept
Given two measured volumes of water, at different temperatures, estimate and compare the resulting temperature when they are mixed.	Equilibrium

Materials needed:

two containers of water, different temperatures
data sheet

Learning activities:

1. Give the students two samples of water of different temperatures. Have them record their estimation of the resulting temperature when mixed. Have them mix the two samples, measure the temperature, and record. Have students vary the volume and temperature of the water; record. Have students repeat the procedure but vary the volumes and temperature of the samples. Use the following data sheet to record information.

SAMPLE 1		SAMPLE 2		Estimated Temp. of mixture in C°	Measured Temp. of mixture in C°
Vol. in ml	Temp. C°	Vol. in ml	Temp. C°		

2. Introduce the concept of "equilibrium." Use the concept when discussing the resulting temperature of the mixture of water samples above. Have students place a measured volume of hot water in a container and predict what its temperature will be in 24 hours. Ask, "What materials are interacting to produce the equilibrium? What other examples of heat equilibrium can you think of?" Discuss heat equilibrium as it applies to the liquid in a thermometer.

Instructional Objective

Given appropriate materials, demonstrate the expansion and contraction of materials.

Concepts

Expansion
Contraction

Materials needed:

balloons
bottles
one-hole stoppers (to fit bottles)
metal pan
heat source: radiation, gas burner, candle, or hot plate
water
ice
food coloring
steel wire
bimetalic strip
metal washers
meter stick
glass tubing

Learning activities:

1. Have students inflate balloons, place them on or above a warm radiator and observe what happens. Let them rub the

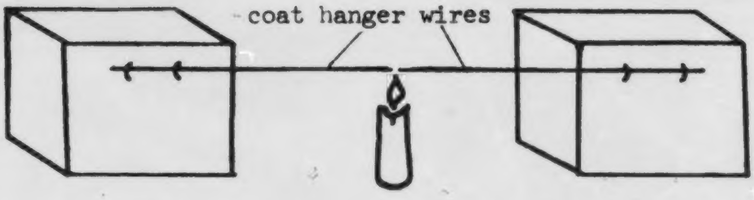
balloons with ice or ice water and observe.

In a learning station or interest center have students place a balloon over the mouth of a bottle, heat the bottle in a pan of water and observe.

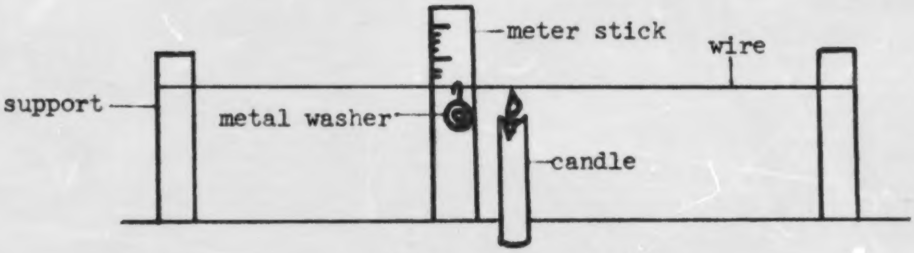
Introduce the words "expansion" and "contraction;" define them.

2. Moisten a piece of glass tubing and insert it with a twisting motion into the hole of a stopper. Fill a bottle with colored water. Place the stopper into the bottle so that the colored water rises in the tube above the level of the stopper. Have students heat the bottle with a pan of hot water and cool it by placing it in a pan of ice water. Discuss other examples of the expansion and contraction of liquids. The thermometer is a good example.

3. The expansion of solids can be demonstrated with a piece of wire. Fasten two pieces of coat hanger wire to separate pieces of wood like those in the diagram below. Place the tips of the wire about 1 mm apart. Heat the wires with a candle or gas burner until the wires touch.



Another method is to stretch a piece of steel wire between two supports. Hang a metal washer on the wire. Measure the height of the washer; heat the wire and measure the height of the washer again.



Caution: Inserting glass rods and heating with candles present safety hazards. Provide close supervision or demonstrate the above activities to the children.

4. Have the children list examples of expansion which occur in everyday life.

Examples:

1. pouring hot water on a lid of a jar so that it can be unscrewed (hot water causes metal lid to expand)
2. railroads - space allowed for expansion
3. joints across concrete highways - allow concrete to expand
4. steel bridge
5. telegraph and telephone wires are strung in a way that will allow for expansion.
6. thermostats

5. Have students observe the interaction of a bimetallic strip with a heat source. Let them offer hypotheses that explain why the strip bends when heated. Let students also suggest uses for the bimetallic strip. (The bimetallic strip is made of two different metals that differ greatly in their ability to expand when heated. The bimetallic strip is used in high temperature thermometers and thermostats.)

Instructional Objective	Concepts
Given appropriate materials, demonstrate melting, boiling, condensing, and freezing.	Melting Boiling Condensing Freezing

Materials needed:

- water
- candle
- ice
- paper cup
- cloth
- hammer
- metal can
- salt

Learning activities:

1. Have an ice melting contest. Provide each student with an ice cube, a cup, and a paper towel. Present a prize to the person who melts his ice cube the fastest or the one who ends up with the most water in his cup. Some may break the ice into small pieces. Others may warm the ice with their hands. Some may blow on the ice. Do not allow students to use any other source of heat than their own bodies.

2. Set up a learning station where students can use a heat source to melt ice and boil the water. Set up another where students use an ice - salt mixture to condense and freeze water on the outside of a metal can.

3. Let students melt and freeze wax. Have them compare the appearance of solid and liquid wax to that of ice and water. Have them tell which has the higher melting and boiling points, wax or water.

Instructional Objective	Concepts
Given appropriate materials, demonstrate the affect of temperature on the dispersion of liquids.	Temperature Dispersion

Materials needed:

tumblers
hot water
cold water
India ink or food coloring

Learning activity:

Provide students with containers. Have students place one drop of India ink or food coloring into a tumbler of cold water and one drop into a tumbler of hot water. Have them compare the speed at which each sample of water disperses the colored liquid.

Instructional Objective	Concept
Given appropriate materials, demonstrate heat transmission by conduction.	Conduction

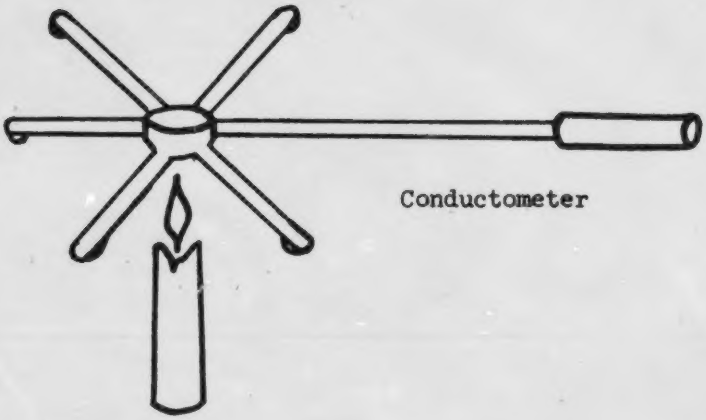
Materials needed:

candle
copper wire (bare)
glass rod
conductometer
tongs

Learning activity:

Make three small wax balls from a lighted candle. Place them on a piece of bare copper wire about 2 cm apart. Hold one end of the wire with tongs and heat the other end in a candle flame. Have students observe what happens to the balls of wax.

Have students use the procedure above to test the ability of other materials to conduct heat. Use a glass rod, coat hanger wire, and other pieces of metal. If a conductometer is available let students use it to demonstrate conduction. Place a piece of wax on the end of each of the metal rods. Heat the center of the conductometer and note the order in which the various rods melt the wax.



Instructional Objective

Concept

Given appropriate materials, demonstrate how heat travels by convection.

Convection

Materials needed:

candle
matches
aquarium or large mouth jar
hot and cold water
food coloring
small jar with lid

Learning activities:

1. (Teacher Demonstration) Hold an unlit match head about 2 cm away from a candle flame. Try it at the sides, below, and above the flame. Ask, "Where is the air around the flame the hottest? What is your evidence?" Repeat the demonstration with a burnt out match.

2. Fill an aquarium or large glass jar with cold water. Insert a small, capped jar of hot colored water into the aquarium. Remove the lid carefully and observe. Try the same activity with warm water in the aquarium and cold colored water in the small jar.

   Introduce the concept of convection, discuss it, and have students try to suggest other examples of it. Discuss convection currents in the room. Have students predict whether the air in the room is warmer at the ceiling or the floor. Let them use a thermometer to check their predictions.

3. Refer to the unit, Forecasting the Weather, for other activities involving convection.

Instructional Objective	Concept
Given appropriate materials, demonstrate how heat travels by radiation.	Radiation

Materials needed:

electric lamp
cardboard
clear plastic or glass
reference materials

Learning activities:

1. Take students outdoors on a sunny day. Let them feel the warmth from the sun. Compare the differences between this type of heat and conduction and convection. State the fact that there is no convection current and that air is not a good conductor of heat. Introduce the concept of radiation and explain that their bodies are absorbing the energy from the sun making them warm.

   Let students feel the warmth from a light bulb in a lamp. Have them shield the bulb with a piece of cardboard and a piece of glass or plastic and describe the results of each. Which material stops more heat radiation?

2. Interested students may be encouraged to find additional information on radiation in reference books. Attention should be given to the wave model and infra-red radiation.

Instructional Objective	Concept
Given appropriate materials, demonstrate heat insulation.	Insulation

Materials needed:

ice
containers - plastic cups, tumblers, boxes
newspaper
cloth

Learning activities:

1. Announce to students in advance that they will have an ice cube preserving contest. Offer a prize for the student who can keep his or her ice cube the longest. The ice cubes will all be kept in the classroom and no refrigeration of any kind will be allowed. Introduce the concept of insulation. Allow them to use any insulator they want to. The class may wish to agree to limit the size of container allowed.

After the contest, have students compare the relative effectiveness of various insulators and techniques used.

# 2. Have students make a bulletin board display of pictures illustrating examples of insulation. Some examples they may use are: thermos bottles, houses, clothing, bed covers, sleeping bags, food coolers, bread warmers.

They may also include a list of materials that are good insulators, such as: rock wool, glass wool, plastics, cloth, paper, asbestos, and air.

Instructional Objective	Concept
Given reference materials, find the contributions of scientists to the study of heat.	Scientists

Materials needed:

reference books and other media

Learning activity:

Have students use reference books and other media to find the names of people who made significant contributions to the knowledge of heat. Have them report the names and the contributions these people made. Some important names to include are: Robert Boyle, Sir Humphrey Davy, Count Rumford (Benjamin Thompson), and John Dalton.

INstructional Objective	Concept
Given reference material, identify commercial, industrial, and consumer uses of heat.	Uses of heat

Materials needed:

reference materials

Learning activity:

# Have students use reference books and other media to find ways heat is used in industry, commerce, and the home. These may be listed, described, and/or classified. Uses of heat may be classified as direct and indirect. Indirect uses would involve the transfer of heat energy into motion, light, chemical change, electricity, or magnetism.

The following objective is strictly optional. Many children will handle it well. Others may find it too abstract.

Instructional Objective	Concept
Given appropriate materials and information, use the kinetic-molecular model to explain the effect of heat on materials.	Kinetic-Molecular Theory

Materials needed:

reference books and other media
charts and other materials used in this unit

Learning activities:

1. Present the following questions to your students:
   Why do materials expand when heated?
   Why do materials change form when heated?
   Why do liquids disperse faster in hot water than cold water?
   Why can heat travel by conduction?
   Why can heat travel by convection?

   Have students find information about the kinetic-molecular theory in reference books or if necessary present it to them. Let them try to use it to answer the questions above or to explain other heat phenomena.

2. Let students demonstrate the increase of speed of molecules by using their bodies. Place a group of students in a "bunch" in the front of the room. Tell them to vibrate in place. As you "turn up the heat" have them vibrate faster and farther apart. Use this to demonstrate expansion, melting, and boiling.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

144	Fire: What Makes It Burn
410	Heat: Molecules in Motion
2048	Learning About Heat

Filmstrips

6682	The Cause and Nature of Heat (Heat, Light, and Sound)
5995	Heat Changes Things
6683	How Heat Causes Expansion (Heat, Light, and Sound)
6684	How Heat Travels (Heat, Light, and Sound)

Filmstrips (Continued)

6063	How Heat Travels
6110	How Man Uses Fuels
7750	An Introduction to Heat (Introduction to Matter and Energy)

A-V Media Approved for Purchase

Filmstrips

Jam Handy

Heat (4 Filmstrips)

- The Cause and Nature of Heat
- How Heat Causes Expansion
- How Heat Travels
- Heat Changes Things

Popular Science Publishing Company

Measuring Temperature

Sound Filmstrips

Crowd Associates

Investigating Relationships in Matter (4 Filmstrips/4 Cassettes)

Heat and Temperature Relationships

LIGHT

Background

Light is the form of radiant energy that enables us to see. Light is a small fraction of the energy radiated from the sun. Other forms of radiant energy are heat, radio waves, and Xrays.

Properties of Light. Light travels in straight lines. It can be reflected, refracted, and absorbed. Objects that produce light are said to be luminescent. Objects that are not luminescent are seen by reflected light. The more important variables of light are intensity and color.

The intensity of a light source depends on the amount of energy produced and the distance from the viewer (or other energy receiver). The intensity of a light source is inversely proportional to the square of the distance from the source. For example, the light from a given distance will be one-fourth as bright at twice that distance, one-ninth as bright at three times that distance, and one-sixteenth as bright at four times that distance.

When white light passes through a glass prism it is separated into the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet. These blend into each other and form the spectrum of visible radiation.

Radio waves, infra-red light, ultraviolet light, Xrays, and gamma rays are invisible parts of the radiation spectrum.

Paints of different colors can be mixed to form new colors. The primary colors, red, yellow, and blue, can be mixed to form green, orange, and violet. Lights of different colors can also be mixed to form new colors. The three primary colors of light, red, green, and blue, can be mixed to form yellow, magenta, and blue-green.

The color that an object reflects is the color that is seen. A green object reflects green and absorbs all other colors. A white object reflects all colors and a black object absorbs all colors.

Transmission of Light. Light can travel through empty space and through some materials. Light travels through space at a speed of 186,282 miles a second. It travels more slowly through materials. Materials that allow light to pass through so the objects can be seen clearly are called transparent. Materials that scatter light and produce a blurred and obscured image are called translucent. Materials that permit no light to pass through are called opaque. Opaque objects produce shadows. When light falls on the surface of an object, it is reflected, refracted, or absorbed.

Light reflected from a smooth surface reflects in a straight line and does not spread out. This accounts for images being clearly seen in a mirror. Light is reflected from a smooth object at the same angle it is received. The angle of reflection equals the angle of incidence. Rough surfaces, such as paper, follow the same law but spread the light out so that no image is formed.

Refraction occurs when light passes through a substance such as water or glass. The light slows down causing it to bend. If a stick is placed into water, it appears to bend sharply at the surface. Lenses made of glass or other transparent material, are used to bend light in specific ways for specific purposes.

Lenses may be diverging, in which the rays are bent apart. These lenses are thinner in the middle and wider at the edges. They are called concave lenses. Converging lenses are thicker in the middle and thinner at the edges. They are called convex lenses. They bend light rays together and focus at a point.

The bending of light by lenses produces real and virtual images. Images that can be shown on a flat surface such as those produced by a projector are real images. A double convex lens can produce a real image. A virtual image is produced as the viewer looks through a lens or a system of lenses. Lenses can be used to magnify images, reduce them, make them appear closer or farther away.

When an object absorbs light, its temperature is usually raised. This is why dark clothes are warmer than light clothes. Dark colors absorb light and light colors reflect light. In an instrument called a radiometer, reflection and absorption of light causes a small mechanism to rotate. A radiometer transforms light energy into motion and can be used to measure light energy.

Production of Light. Light can be produced by heating an object until it glows. As greater amounts of heat are added to the object, it glows brighter and changes color from red to orange, to yellow, to white, to blue-white. This process is called incandescence. Some materials such as barium sulfide, egg shells, gelatin, and paraffin can produce light by phosphorescence. These materials absorb light from another source and then give off their own light. Some animals such as fireflies, glowworms, jellyfish, and mushrooms produce light by a process called bioluminescence.

Light Models. At one time light was believed to consist of particles, called corpuscles, which were supposedly emitted from luminous bodies. Later a wave theory was developed. A more recent development is a theory of radiation called the quantum theory in which light is believed to be emitted in small packages called quanta or photons. These are believed to behave like both particles and waves.

An atom is surrounded by electrons that whirl rapidly around the nucleus in concetric circles or shells. According to the quantum theory, when atoms are heated the electrons in the second shell move so fast that they jump to the first shell. The energy needed to revolve in the first shell is less than what is needed in the second shell. The excess energy is given off as a photon of light.

There are no investigations on light theory in this unit because this concept is too complex and abstract for most intermediate grade children.

Rationale

The unit Light is designed to help children (1) identify and describe the properties of light,(2) identify and describe the interaction of light with material objects, and (3) investigate light as it relates to color.

Sight is one of the major ways in which people experience the universe. Light is the form of energy which makes sight possible. Light and color provide a wide variety of activities that interest and stimulate imagination and learning.

Glossary of Concepts

Light	A form of radiant energy.
Light Source	An object that produces light; a luminous body.
Reflection	The bouncing of light off the surface of an object.
Light Transmission	The movement of light energy through space or matter.
Intensity	The brightness of light.
Transparent	The property of a material that permits light to pass through it so that objects can be seen through it clearly.
Translucent	The property of an object that scatters light that passes through it.
Opaque	The property of a material that does not permit light to pass through it.
Shadow	The dark silhouette - image of an opaque object.
Diffusion	The scattering of reflected or refracted light.
Absorption	The retaining of light energy by an object.
Angle of Incidence	The angle made by a line perpendicular to a mirror and the line from the mirror to the object.
Angle of Reflection	The angle made by a line perpendicular to a mirror and the line from the mirror to the reflection of the object.
Refraction	The bending of light rays that pass from one medium to another.
Lens	An object made of glass or other transparent material that bends light into a convergent or divergent pattern.

Concave Lens	A lens that is thinner in the middle than it is at the edges; a lens that spreads out light.
Convex Lens	A lens that is thicker in the middle than it is at the edges; a lens that focuses light.
Virtual Image	An image of the type seen by looking into a mirror or through a lens; an image that fools the eye and has no real physical existence.
Real Image	An image of light, shade, and/or color that can be projected on a surface.

Investigations

Instructional Objective	Concept
Given appropriate materials, identify the conditions which permit objects to be seen.	Light

Materials needed:

- shoeboxes
- black construction paper or black paint
- flashlight
- candle
- lamp
- small objects (ball, paper cup)

Learning activities:

1. Have students compare how well they see objects and colors under varying amounts of light. Darken the room and have them describe objects as seen from various distances under different amounts of light. Use candle light, a flashlight, a lamp, light from one window, and the overhead lights to provide varying amounts of light.

2. Instruct students to cover the inside of shoeboxes with black paper or black paint. Have them make a hole in one end of each box. Let them put objects into the box and try to see the objects by looking through the hole. Ask them to do something to the box that will enable them to see the object.

   Introduce the concept of "light" and guide students in developing definitions of light. Help students make a list of conditions necessary for objects to be seen.

Instructional Objective	Concepts
Given a collection of objects, identify those that are sources of light.	Light source Reflection Luminous body

Materials needed:

object collection including:
- light bulbs
- candles
- electric hot plate
- flash light
- filmstrip projector

Learning activity:

Provide students with the collection of objects listed above. Light the candle and turn on the other objects. Ask the children to classify the objects into two groups, those that produce light and those that do not. Ask questions such as, "What forms of energy other than light are produced by these objects? Do all light sources produce heat? What are some sources of "cold light?"

Write something on the chalkboard. Turn on a filmstrip projector and point it toward a dark object such as a piece of black paper, or another section of the chalkboard. Have the students try to read what is written on the chalkboard. Place a piece of white paper in front of the projector so the light reflected from it falls on the chalkboard. Ask, "Is the chalkboard easier to read now than before? Why? or why not? Is the white paper a light source?"

Introduce and discuss the concepts of "light source," "luminous body," and "reflection."

Instructional Objective	Concept
Given appropriate materials, demonstrate that light travels in a straight path.	Light transmission

Materials needed:

- plastic drinking straws
- index cards
- clay
- flashlight
- reference materials

Learning activities:

1. Make a hole in the center of each of four index cards. Support them by inserting them into pieces of clay. Have students arrange the cards so light from a flashlight can pass through each card. Have students describe the allignment of the cards. Ask, "What happens when one card is moved out of line?"

2. Have students look through drinking straws at a dim light source, bend the straws, and describe what they can and cannot see.

Instructional Objective	Concepts
Given appropriate materials and various light sources, identify the variables that determine the intensity of light.	Intensity Transmission

Materials needed:

- paraffin blocks
- aluminum foil
- rubber bands
- candle
- filmstrip projector
- flashlight
- light meter(if available)
- light bulbs of different wattages

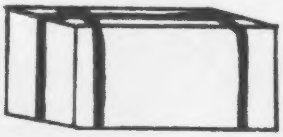
Learning activities:

1. Darken the room. Shine a flashlight on the chalkboard from the back of the room. What happens to the light as the flashlight gets closer to the board? Shine the flashlight on the board from the middle of the room. Shine the filmstrip projector on the board from the same distance. Shine both at the same time. Discuss the difference in the appearance of the light. Turn on one row of lights in the darkened room. Observe the lights in the room. Turn on a second row of lights and compare. When children have determined there is a difference in the brightness of the lights, introduce the concept of "intensity."

   Have the children identify the variables that determined the differences in the intensity of the light.

2. If possible, bring a light meter to class. Instruct students in the use of the light meter. Let them measure the intensity of light in different parts of the room and identify the brightest and darkest places in the room.

3. Have children make a device to compare the intensity of different light sources. Use two blocks of paraffin that are the same size. Cut a piece of aluminum foil twice the size of one block of paraffin. Fold foil in half so the shiny side is out. Place the foil between the two blocks of paraffin. Use rubber bands to hold the foil and paraffin together.

   Darken the room. Have students place two light sources of different intensities equidistant from the faces of paraffin blocks. Let them compare their intensities by observing the relative brightness of the two blocks. Have them move the two light sources so the brightness of the two blocks are equal. Measure and compare the distances of the light sources from the blocks.

4. Have students compare the intensities of an incandescent lamp and a florescent lamp of equal wattage. Have them identify the advantages and disadvantages of each of these two sources of light.

5. Focus the light from a filmstrip projector on the chalkboard from a distance of two meters. Have students compute the area of the rectangle formed by the light. Move the projector back two meters and have students compute the area again. Move the projector back two more meters and have students once more compute the area. If a light meter is available, have students measure the intensity of the light reflected from the chalkboard for each trial.

   Repeat the procedure but start by having the projector three meters from the chalkboard. Move it back to six meters and let the students predict what the area of the rectangle will be. Have them measure the rectangle, calculate the area, and check their predictions. Discuss how distance from a light source affects its intensity.

Instructional Objective	Concepts
Given a set of materials and a light source, classify materials as transparent, translucent, or opaque.	Transparent Translucent Opaque Transmission

Materials needed:

light sources (flashlights, dry cells, and bulbs)
variety of materials (wax paper, clear plastic food wrap, glass, aluminum foil, cloth, paper, plastic, rubber)

Learning activity:

Distribute a set of various materials and a light source to pairs or small groups of students. Ask them to sort the materials by the way they interact with light. Have students describe the interactions. Cover one flashlight with clear plastic wrap, one flashlight with wax paper, and one flashlight with aluminum foil. Shine each flashlight on the chalkboard or a wall. Discuss what happens to the light in each case. Introduce the concepts of "transparent," "translucent," and "opaque." Ask children to try to define each term. If they cannot, have students find each term in a dictionary.

Have students make a chart classifying these and other materials as transparent, translucent, or opaque.

Translucent	Transparent	Opaque
Wax Paper Light Window Shade	Plastic Wrap Glass Window	Aluminum Foil Book Table

Instructional Objective	Concepts
Given appropriate materials, identify the variables that affect the properties of a shadow.	Shadow Variable

Materials needed:

- cardboard
- straight pins
- flashlight
- filmstrip projector
- lamp with clear and frosted light bulbs
- object collection

Learning activities:

1. Let students use various light sources and an object to explore shadows. Have them compare the properties of shadows cast by different light sources.

2. Provide students with a list of properties and have them try to make shadows that have these. Some properties to use are: round, square, long, short, dark, light, clear, fuzzy, pointed, and checkered. Discuss ways shadows are formed and have students identify the variables that determine the formation of shadows having a specific property.

3. Have students use a light source and straight pins to make shadow patterns. The pins may be stuck into a piece of cardboard. Have students draw a simple geometric shape, outline it with pins, and try to make the pin shadows fall first outside the drawing, then inside the drawing. Let students experiment making different shadwo patterns with pins.

4. Let students explore making shadow patterns with liquids on an overhead projector. Place small amounts of colored liquid with various objects to make moving patterns.

Instructional Objective	Concepts
Given a light source and a collection of objects, identify properties of the light reflected from the objects.	Reflection Diffusion Absorption

Materials needed:

- flat mirror
- spoon
- waxed paper
- foil (smooth and rough)
- paper of various colors

Learning activities:

1. In a darkened room, shine a filmstrip projector toward one end of the room. Have the children face the opposite end. Hold different materials in the path of the light. Have students discuss properties of the light reflected from each object. Discuss how each object affected one's ability to see. Introduce and discuss concepts of reflection and diffusion.

2. Have nine children stand side by side in front of the room facing the class. Have one student, holding a mirror, stand about three meters away, facing the middle child. As each student to tell who he or she sees in the mirror. Have another student use a piece of twine to show the path of vision from one person to the mirror to the person seen in the mirror.

3. If available, let students investigate curved mirrors. They may tape flat mirrors together to make curved mirrors.

# 4. Discuss uses of mirrors in business and industry. Make a list of the various uses.

Instructional Objective	Concepts
Given appropriate materials, measure and compare the angle of incidence and the angle of reflection.	Angle of incidence Angle of reflection

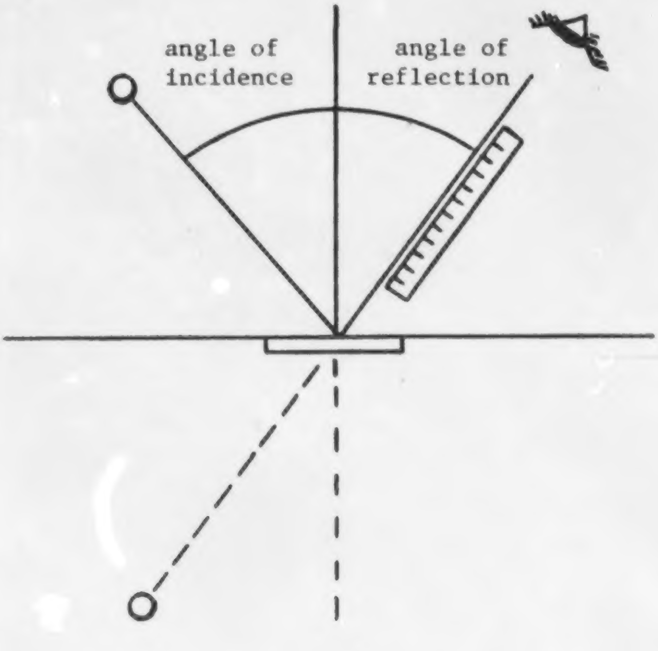
Materials needed:

- mirror
- paper
- flashlight
- protractors
- black paper
- ruler

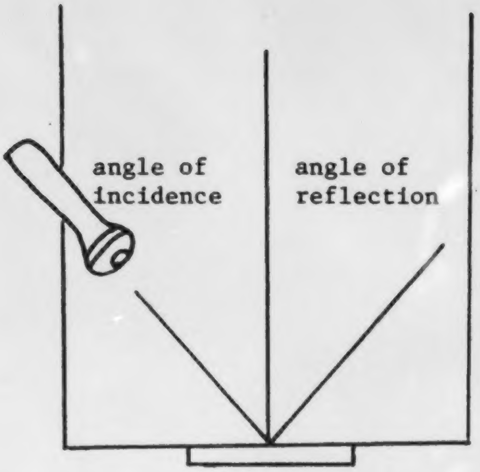
Learning activities:

1. Have students use the following methods to measure the angle of incidence and the angle of reflection. Help them identify these two angles and formulate a statement about how they compare.

   a. Place a mirror along one edge of a piece of paper. Draw a dotted line perpendicular to the mirror. The line is perpendicular when it and its reflection form a straight line. Place an object on the paper 4-8 cm from the line and a similar distance from the mirror. Draw a line segment from the object to the point where the perpendicular strikes the mirror. Place a ruler on the paper so that the edge of it is in line with the reflection of line segment. Use a protractor to measure the angle of incidence and the angle of reflection as shown in the drawing below, or cut out the angle of incidence and place it on the angle of reflection. How do they compare?



   b. Cover a flashlight with black paper, cut a narrow slit from the center of the paper to one edge. Fold a sheet of paper in half, put it flat on a table and place a mirror along the edge of the paper as shown in the following drawing. Darken the room, shine the flashlight into the mirror so the beam of light strikes the mirror at the point where the fold meets the mirror. Trace the path of light with a pencil, and compare the angle of incidence to the angle of reflection.



# 2. Have students roll a golf ball against a wall and compare the angle of incidence to the angle of reflection. Discuss how this knowledge could help a person play games such a billiards and miniature golf.

Instructional Objective	Concept
Given appropriate materials, illustrate refraction of light by water.	Refraction

Materials needed:

- pencil
- glass or plastic tumbler
- water
- paper cup
- coin
- aquarium
- milk
- flashlight

Learning activities:

1. Place a pencil in a glass of water. Have students observe it from many different angles and describe its appearance.

2. Put a coin into a paper cup. Have one person look at the coin and move back until the coin can no longer be seen. Have another person pour water into the cup while the first person describes what he or she observes.

   Introduce "refraction." Define it and discuss examples of it.

3. Fill an aquarium or a large glass jar with water. Place

a few drops of milk in it and stir. Cover a flashlight with black paper. Make a small hole in the center of the paper. Darken the room. Hit two chalkboard erasers together over the water. Have students shine the flashlight into the water, first straight down, then at an angle and describe what they see.

Instructional Objective	Concepts
Given hand lenses, describe and compare virtual and real images.	Virtual image Real image

Materials needed:

- hand lenses
- white paper
- metric rulers
- clear plastic
- newspaper

Learning activity:

Have students look through hand lenses at different objects. Place a sheet of paper on a wall opposite a window. Have students hold hand lenses close to the paper so that images of the window appear on the paper. Have them describe this type of image and compare it to the image they see when they look through a lens. Introduce and discuss the concepts of "virtual image" and "real image."

Instructional Objective	Concepts
Given a variety of lenses, demonstrate and describe how they bend light.	Lens Concave Convex

Materials needed:

- shoe boxes
- clay
- filmstrip projector
- window shade cord
- aluminum pan
- comb
- scissors
- reference books and other media
- demonstration lenses

Learning activities:

1. Have students construct light boxes and demonstrate lenses as follows:

   Make a round hole about 2 cm in diameter in one end of a shoe box. Make a slot in the lid, large enough to insert a pocket comb, about 5 cm from one end. Make an observation slot in one side of the box about 2 cm x 15 cm. Put a filmstrip projector up to the hole in the end of the box. Mount a demonstration lens on a piece of clay and place it inside the box so the light can shine through it. Light a small piece of window shade cord, blow out the flame, place it in a small aluminum pan and put it inside the box. Put the lid on the box, insert a pocket comb through the slot in the lid, turn on the projector, and darken the room. Look at the rays of light through the observation slot. Make adjustments as necessary.

   Use a variety of lenses and have students describe how they affect the rays of light that come through the comb.

2. Have students explore the properties of different lenses. Let them see if they magnify, focus light, or spread out light. Introduce the names of lenses such as convex, concave, plano-convex, and concavo-convex.

   Have students place clear plastic over a piece of newspaper, place a drop of water on the plastic, and describe the magnifying properties of the various drops of water.

Instructional Objective	Concepts
Given appropriate materials, produce a spectrum and identify the colors in sequence.	Spectrum Color

Materials needed:

glass jar
aluminum foil
water
diffraction grating
prism
cardboard tube

Learning activities:

1. Provide students with glass prisms and jars of water. Have

them use sunlight or light from a projector to produce a spectrum. Have them name the colors they see.

2. Let students make spectroscopes as follows:

> Cover one end of a cardboard tube with aluminum foil. Cut a slit 1 to 2 mm wide and 2 cm long. Cover the other end with black paper. Make a hole about 2 cm square in the paper. Tape a piece of diffraction grating over the hole so that the lines of the diffraction grating are parallel to the slit in the aluminum foil.

Have students use the spectroscope to look at light from different sources such as the sun, fluorescent light, and incandescent lights of various colors.

3. Have a few students use reference books to find information about the laboratory and commercial uses of spectroscopes. Let them report this to the class.

Instructional Objective	Concept
Given reference sources, investigate the uses of light and prepare a presentation illustrating each use.	Uses of light

Materials needed:

- reference materials
- cardboard tubes
- lenses
- mirrors
- tape
- boxes

Learning activities:

1. Have students use reference materials to investigate topics listed below and present their findings to the class through charts, murals, oral reports, or demonstrations.

Topics: laser, range finder, photography, optometry, polarized light, light and color, microscopic work, bioluminescence, use of black light, theatrical lighting.

2. Have students construct any of the following objects: a color wheel, a periscope, a telescope, a camera, a projector.

3. Invite one or more of the following to discuss how light or optics is used in his or her work: an optometrist, a theater lighting engineer, a jeweler, an astronomer, a photographer.

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Materials listed in A-V Media Handbook - 1972

Sound Films

9	How to Bend Light
2049	Learning About Light
65	Light and Color
941	Light: Let's Talk About It
508	Light - On the Subject of Light
2407	Science of Light

Filmstrips

7456	Fundamentals of Science: Light
7457	Fundamentals of Science: Light and Color
7751	An Introduction to Light (Introduction to Matter and Energy)
6635	Light
6686	Light and Color (Heat, Light, and Sound)
6685	Light and How It Travels (Heat, Light, and Sound)

Charts

Davis - Smith Science Charts, A.J. Nystrom Company

Light and Its Characteristics

FORCE, MOTION, AND MACHINES

Background

Force and Motion. One of the most noticeable properties of objects is their motion. Motion occurs as a result of a force acting on an object. A force is a push or a pull. Some of the forces that move objects are muscle force, gravity, moving air, moving water, magnetism, electric power, and exploding gases (in gasoline engines). Force must also be applied to a moving object to make it speed up, slow down, change direction, or stop.

Work. When objects are moved, or when the motion of an object is changed, work is done on the object. Work is the result of applying a force on an object through a distance. The amount of work done can be calculated by multiplying the amount of force exerted by the distance it is applied. Work = Force x Distance

Energy. An object capable of doing work possesses energy. Energy may be potential or kinetic. Potential energy is stored energy, or energy at rest, such as the energy in a coiled spring, the energy in a rock positioned to fall, or the energy in an electric dry cell. Kinetic energy is the energy of objects in motion. The quantity of kinetic energy in a moving object depends on its mass and speed.

Resistant Forces. Objects resist motion. Whenever objects are moved one or more forces must be overcome. These are generally gravity, friction, and inertia.

Gravity must be overcome when lifting objects. Since the weight of an object is due to the force of gravity attracting it, the force needed to lift an object is equivalent to its weight. The weight of an object creates a pressure between it and the surface on which it rests, therefore gravity is also a factor in sliding objects horizontally.

Whenever an object moves in contact with another object, frictional forces resist the motion. These forces are caused by the adhesion of the two surfaces and by the interlocking of irregularities and "bumps" in the rubbing surfaces. The amount of frictional resistance depends upon the stickiness and texture of the two surfaces and upon the force pressing the surfaces together.

Friction is undesirable when it increases the work needed to accomplish a task. It also causes wear and generates heat. To reduce this waste of energy, wheels, rollers, bearings, lubricants, and streamlining are used. Friction can also be desirable. Nails and screws hold boards together by friction. Power is transmitted by chains, gears, belts, and clutches. It is impossible to exert a force to cause another object to move without friction. Walking or driving on ice is difficult because there is too little friction between the shoes, or the tires, and the ice.

Inertia is the tendency of an object at rest to remain at rest and the tendency of an object in motion to remain in motion at the same speed and in the same direction. Newton's law of inertia states that changes in motion require force. It takes less force to keep an object moving than it does to start it moving. Force is also required to make a moving object speed up, slow down, change direction, or stop.

Machines. Machines are devices used to apply energy to do work suitable for a given purpose. Machines are used to make work easier. They have no energy of their own. Their output can be no greater than the work put into them. Machines can transfer force, change the direction of a force, increase force,and increase distance and speed.

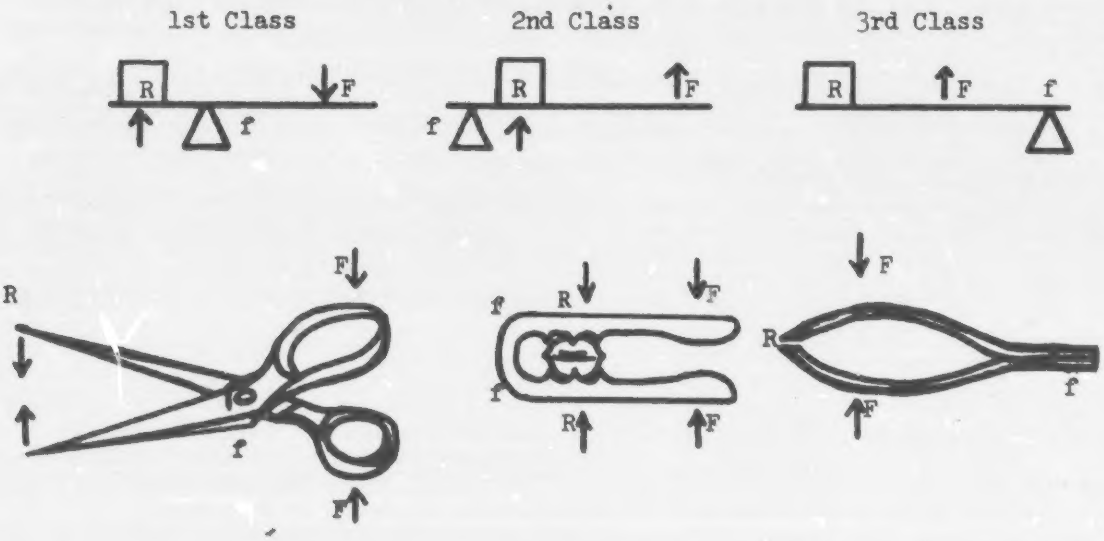
A machine that increases force trades distance to gain force. The force is applied through a greater distance than the object is actually moved. A machine that increases distance trades force for distance. A great deal of force is applied over a relatively short distance but the object is moved rapidly over a far greater distance.

All machines, regardless of their complexity, are composed of one or more fundamental simple machines. In each simple machine, the energy is supplied by a single force and the machine does useful work against a single resisting force. The types of simple machines are the lever, the pulley, the wheel and the axle, and the inclined plane.

Lever. A lever is a rod or bar that pivots on a small surface called a fulcrum. A teeter-totter, an equal arm balance, a crowbar, a baseball bat, and a rowboat oar are all examples of levers. Levers also come in pairs called double levers such as scissors, pliers, nail clippers, and ice tongs.

Levers are classified as first, second, and third class depending upon the relative position of the force, the fulcrum, and the resistance.

CLASSES OF LEVERS


1st Class

2nd Class

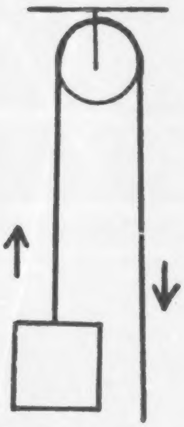
3rd Class

A first class lever changes the direction of the force. It will increase force if the fulcrum is relatively closer to the resistance but will increase distance if the fulcrum is closer to the force. A crowbar, a teeter-totter, and an equal arm balance are first class levers. Examples of double first class levers are scissors and pliers.

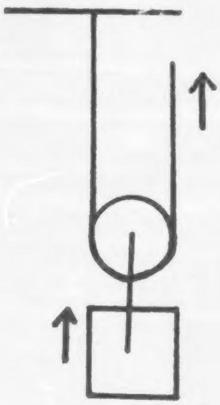
A wheelbarrow and a nutcracker are examples of second class levers. These do not change the direction of the force but do increase force.

A baseball bat, a golf club, and forceps are examples of third class levers. These also do not change the direction of the force but they do increase distance and speed.

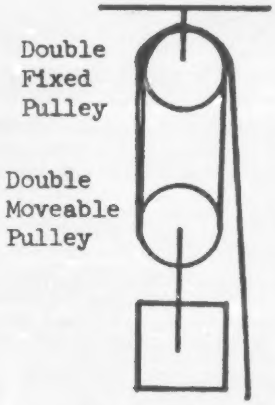
Pulley. A pulley is similar to a lever but uses a grooved wheel rather than a fulcrum and a rope or chain rather than a rod or bar. A pulley may be fixed or movable. A fixed pulley can only change the direction of the force. It is useful in transferring energy to hard to reach places, such as the pulley on a flag pole. Movable pulleys are used to increase force. Pulleys can be grouped together to gain greater advantage in increasing force.



Single Fixed Pulley



Single Moveable Pulley



Double Fixed And
Double Moveable Pulley

Wheel and Axle. A wheel that turns with its axle is called a wheel and axle. The wheel need not be complete to be considered a wheel and axle. The handle on a pencil sharpener is a one spoke, rimless wheel. The blades of the pencil sharpener are on the axle. The ratio between the radius of the wheel and the axle enable the machine to increase force or distance. A door knob is a wheel and axle in which the force is applied to the wheel. The work is done on the axle where the force is increased. A merry-go-round is an example of a wheel and axle in which the force is applied to the axle. The work is done on the wheel where the speed is increased. Gears, pinions, chains, and belts are often used to transfer force from one wheel to another.

Inclined Plane. An inclined plane is a sloping flat surface. It is a simple machine with no moving parts. A driveway, a ramp, and a house roof are examples of inclined planes. It is easier to push a heavy object up an inclined plane than it is to lift it straight up, however, the force must be applied over a greater distance.

A wedge consists of two inclined planes put together. An axe blade, a door stop, and a knife blade are examples of wedges.

A screw is an inclined plane wrapped around a cylinder. Its compactness makes it a very convenient device. The screw principle is used on jar lids, airplane propellers, screw conveyers, and auger bits.

Mechanical Advantage. Mechanical advantage is the ratio of the output force on the load to the input force (effort) exerted on the machine. For example, a lever that enables a person to lift a 300 pound refrigerator by using 30 pounds of force has a mechanical advantage of 300/30 or 10. A machine designed to increase force will have a mechanical advantage greater than 1. A machine designed to increase distance and/or speed will have a mechanical advantage less than 1.

Efficiency. Because of friction, the useful work of a machine (the output work) is always less than the work done on the machine (the input work). The efficiency of the machine is the ratio of the output work to the input work and is always less than 1.

Rationale

The unit Force, Motion, and Machines is designed to help children (1) to communicate descriptions of the position and motion of objects, (2) investigate the forces at work in moving objects, and (3) understand and appreciate the function of machines.

Every child has had experience working with tools that provide background for studying forces, energy, and machines. Children expend energy, exert force, and do work. They also have many experiences with other kinds of force in toys, home appliances, and various means of transportation.

Glossary of Concepts

Relative Position	The location of an object in relation to a reference.
Frame of Reference	An object or system used to describe the position or motion of another object.
Motion	An change of position in relation to a fixed frame of reference.
Speed	The rate at which an object moves; the ratio of distance to time.
Direction	The line or course of motion.
Straight Line Motion	The motion of an object moving in one direction; also called rectilinear motion and translation.

Rotation	The spinning of an object around a point.
Vibration	A back and forth or up and down motion.
Force	A push or a pull; the cause of the movement of an object.
Push	A force applied in a direction away from the source of energy.
Pull	A force applied toward the source of energy.
Action-Reaction	A force and its accompanying counter force; for every action there is an equal and opposite reaction (Newton).
Resistance	A force that restrains or opposes an object's motion.
Inertia	The tendency of an object to remain at rest, or in motion in a straight line at a constant speed.
Gravity	The force of attraction between the earth and another object.
Magnetism	The attracting and repelling forces of a magnet.
Friction	The rubbing together of moving objects.
Efficiency	The ratio of output work to the input work of a machine.
Lubricant	A material placed between moving parts to decrease friction.
Bearing	Rollers or balls used inside wheels to reduce friction.
Energy	The ability of an object or a material to do work.
Potential Energy	Stored energy.
Kinetic Energy	The energy of an object in motion.
Work	The result of exerting a force through a distance.
Machine	An object which facilitates work, making it easier.
Simple Machine	A machine that utilizes a single force against a single resisting force; one of the four fundamental categories of mechanical devices that facilitate work.
Conservation of Energy	The principle that the total amount of energy in a system remains constant during an energy transfer.

Mechanical Advantage	The ratio of force output to the force input.
Lever	A rod or bar that turns on a fulcrum or pivot.
Pulley	A grooved wheel.
Inclined Plane	A sloping, flat surface.
Wheel and Axle	A machine consisting of a wheel or part of a wheel that turns with its axle.
Screw	A inclined plane curved around a cylinder.
Wedge	Two inclined planes put together.
Energy Source	An object or system that transfers energy.
Energy Receiver	An object that receives energy from another object.
Energy Transfer	The movement of energy from one system to another.
Machinery	A system or assemblage of machines.

Investigations

Instructional Objective	Concepts
Given an object at rest, describe its position in relation to a given frame of reference.	Relative position Frame of reference

Materials needed:

box
ball, or other object
doll, puppet
blindfold

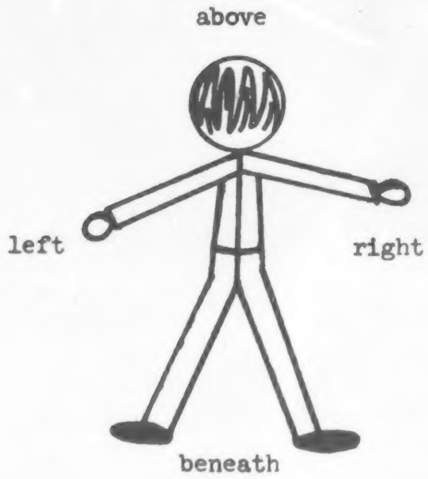
Learning activities:

1. Place a ball, or other object, near a cardboard box and have students tell where the ball is in relation to the box. Encourage students to use phrases such as," In the box; near the box; on the box; under the box; and to the left of the box." Also encourage them to use complete sentences. Introduce "relative position" and "frame of reference." Ask students to identify the position of the ball and the frame of reference they used.

2. Have students describe the position of an object in relation to themselves. Let them try to describe the position of an object in relation to another person.

Do the same activity but use a doll or a puppet as the frame of reference. Put the doll or puppet in various positions as students describe the position of the object in relation to it. Let the doll (1) face upright away from the students, (2) face upright toward the students, (3) stand on its head facing the students, (4) stand on its head facing away from the students, (5) lie on its back, and (6) lie on its stomach. The descriptions of the position of the object become confusing and difficult. Remind students that the frame of reference is the doll, not the earth.

The drawings below may help the teacher.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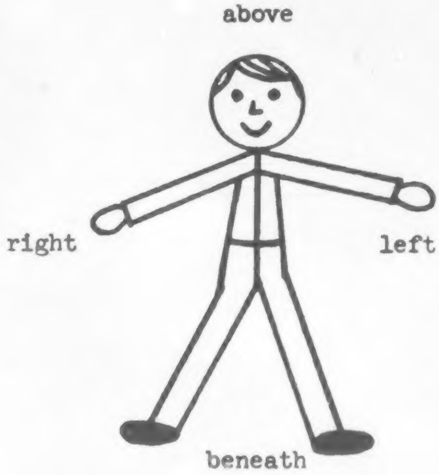
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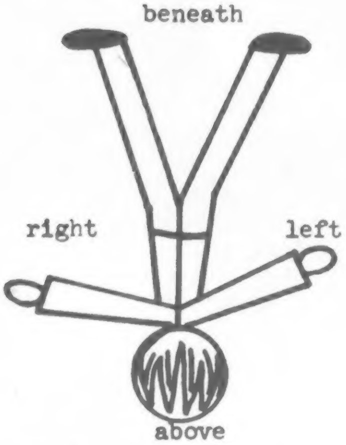
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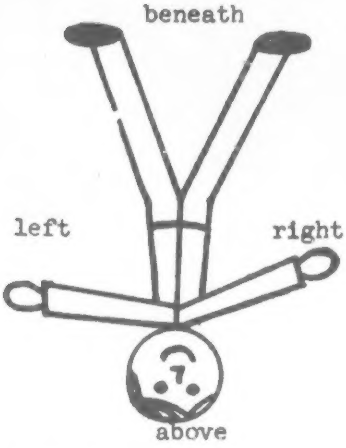
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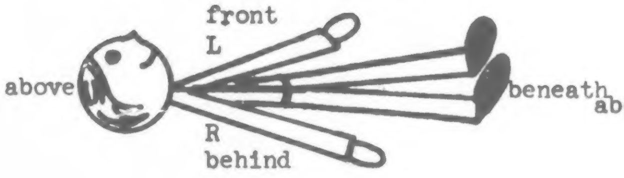
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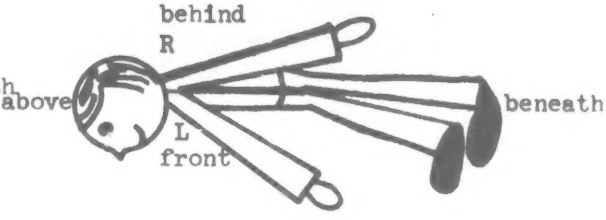
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3. Blindfold a child. Have some one give a series of directions that lead the child to a specific object.

   Have students practice giving directions to another person and identify the reference objects used.

Instructional Objective	Concepts
Given an object in motion, describe its motion.	Motion Frame of reference Speed Direction Straight-line motion Rotation Vibration

Materials needed:

- objects that move
- tape
- large box
- tennis balls

Learning activities:

1. Develop a collection of toys and other objects that move. Maintain and add to this collection throughout this unit. Take a walk through the school and into the community and have students list objects that move. Have students describe the motion of these objects. As this is done, review the frame of reference concept. Encourage students to describe motion in terms of a fixed frame of reference. For example: "The hands moved around the clock. The spring bounced up and down on its support. The ball went through the basket."

2. Make a class list of words that describe motion. Include terms that denote: (1) speed, such as fast, slow, miles per hour, feet per second, and meters per second; (2) direction, such as in, out, up, down, left to right, toward, away, north, south, clockwise, and counter clockwise; and (3) regularity or irregularity, such as continuous, constant, smooth, even, intermittent, eratic, rough, uneven, and bumpy.

   Introduce and discuss "straight line motion," "rotation," and "vibration."

3. Have students describe the motion of an object in relation to a moving frame of reference. Pose questions such as: "If two cars are traveling side by side, how would an observer in one car perceive the motion of the other car? If one car is going five miles per hour faster than the car in front, how does an observer in that car perceive the other car? In baseball, what things must a batter consider as he tries to hit the ball? In football,

where does a quarterback try to throw the ball in relation to a moving receiver?"

Have one child run, carrying a box, while others try to throw tennis balls into the box.

# 4. Discuss the special skills a person must develop, related to motion, if he or she is considering a career in sports or transportation.

Instructional Objective	Concept
Given moving objects, measure and compare their speed.	Speed

Materials needed:

objects that move: ball, bat, toy cars
stopwatch
meter sticks, yardsticks, measuring tape
chart paper

Learning activities:

1. Have students measure and compare the speed of moving objects such as; students running, a thrown ball, a ball hit with a bat, toy cars. Have students time the motion with a stopwatch, measure the distance with a meter stick, yardstick, or tape measure, and report the speed in meters per second, or feet per second.

2. Let students use reference books to find the speed of various things such as; living organisms, jet airplanes, rockets, satellites in orbit, sound, and light. Have them record the speeds on a chart or graph. Refer to the chart in discussing the variables that enable an object or energy form to move at a particular speed.

# 3. Discuss how the speed of various means of transportation affect people's work. Consider such things as where people live in relation to their work, what it means to commute, the importance of good roads, and public transportation.

Instructional Objective	Concepts
Given objects in motion, identify the forces causing the motion.	Force Push Pull

Materials needed:

twine
paper tube
objects that move: a clock, a phonograph, an hourglass eggtimer, a top, balloons, other toys that move

Learning activities:

1. Stretch twine or wire across the room. Hang a paper tube or some other object on it. Let students move the tube on the string or wire in as many different ways as they can.

   Introduce the concept of "force." Have students identify the forces used to make the tube move.

2. Have students identify the forces that cause various objects to move. Use the class collection and other moving objects in the school, home, and community. Have them classify the forces as either a push or a pull.

Instructional Objective	Concepts
Given appropriate materials, demonstrate the principle of action-reaction.	Push Pull Action-reaction

Materials needed:

- balloons
- chairs
- bicycle
- reference materials

Learning activities:

1. Have students analyze the forces at work when they walk and ride a bicycle. Ask, "Are you pushing or pulling? Which direction? Which direction do you move?"

2. Have two students sit in chairs with their feet off the floor and try to push one another. Ask, "What else is needed to move an object besides force?"

   Introduce the concept of "action-reaction." Have students use reference books to find information about Newton's Third Law of Motion.

3. Have someone blow up a balloon and release it. Ask, "What forces made the balloon move? What direction did the air move? What direction did the balloon move? What was the air pushing against?"

4. Let interested students draw pictures and diagrams to illustrate the action-reaction principle.

Instructional Objective	Concepts
Given moving objects, identify the forces resisting the motion.	Resistance Inertia Gravity Magnetism Friction

Materials needed:

- playground equipment
- toy wagon
- chairs
- bicycle
- paper
- tumblers
- file cards
- coins
- plastic bottles

Learning activities:

1. Have students slide, lift, push, and pull objects to move them. Have students push one another in chairs or, if possible, in a wagon, on a bicycle, or in a swing. Let students slide objects on both rough and smooth surfaces. Ask, "Which example was the most difficult to move? Why do you think it was so difficult? Which was the easiest? Why?"

2. Introduce the concept of "resistance." Ask students to identify the forces that resist motion in each of the examples above. Introduce "inertia," "gravity," and "friction" as needed in the discussion. Ask such questions as: "Why is an object with a greater mass harder to lift than one with less mass? Why is it easier to push an object on a smooth surface than a rough surface? When pushing someone in a wagon, why is it harder to get them started than it is to keep them going once it is started?"

3. Have students place a card over a tumbler, place a coin on it, and flip the card so the coin falls into the tumbler. Let them try to pull a sheet of paper out from under a plastic bottle without upsetting it. Ask, "What was the energy receiver in each of these examples? Why did the coin not move with the card? What forces were involved? Which force was the greatest?"

#4. Have students bring toy cars to class and race them by rolling them down a ramp. Ask, "How can the speed of a car be increased? What can be done to reduce the friction? How are automobiles shaped to reduce wind resistance? How are other vehicles designed to reduce resistance to wind, water, or rubbing?"

Instructional Objective

Given appropriate materials, demonstrate the effects of friction on moving objects and identify the reasons for decreasing and increasing friction.

Concepts

Friction
Efficiency

Materials needed:

- wood blocks
- metallic objects
- pieces of plastic
- sandpaper
- rubber erasers
- soap
- water

Learning activities:

1. Have students rub objects of various textures together and feel them. Ask them to give other examples of rubbing that produce heat.

   Let someone push a heavy box over a rough surface, then ask the class what might be done to reduce the rubbing.

   Discuss reasons why it is desirable to decrease friction in moving systems. Introduce the concept of "efficiency" and discuss the loss of work input because of friction.

# 2. Have someone try to turn a doorknob with soap on his or her hands. Let two people try to have a tug-of-war with soapy hands.

   Ask students to describe what it is like to try to walk on ice. Ask for other examples of situations friction is desirable.

   Have students draw pictures or prepare an exhibit showing ways to increase friction. Let them investigate the design of rope fibers, tire treads, stair treads, street surfaces, bath mats, handle bar grips, and gripping tools such as pliers and wrenches.

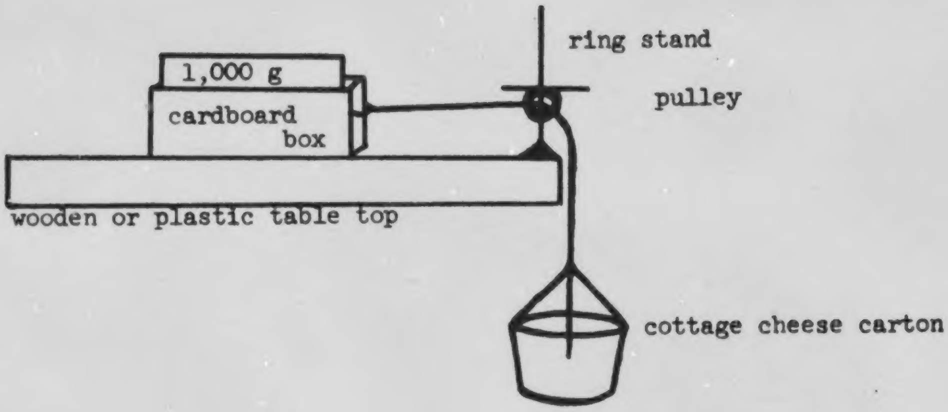
Instructional Objective	Concepts
Given a variety of surfaces, compare their frictional force.	Friction Lubricant Bearing

Materials needed:

ring stand with ring or clamp
table with wooden or plastic top
cardboard box
1 kg weight
pulley
twine
cottage cheese carton
gram weights

Learning activities:

1. Set up the apparatus pictured on the following page and have students do the following:
   Add weights to the cottage cheese carton until the weighted box begins to move. Record the results on the chart on the next page. Staple a piece of sandpaper to the bottom of the box and record the weight necessary to slide the box across the table.



Place a piece of sandpaper on the table, sand side up, and repeat the procedure. Try combinations listed on the chart below. Identify the surfaces that exert the least frictional force.

Surfaces Used	Weight Needed to Move Box
cardboard on wood	
cardboard on paper	
cardboard on wax paper	
cardboard on foil	
sandpaper on wood	
sandpaper on paper	
sandpaper on wax paper	
sandpaper on foil	
sandpaper on sandpaper	
cardboard on glass	
foil on wood	
foil on foil	
foil on foil with oil	
foil on glass with oil	

# 2. Invert a coffee can and place it on a flat level surface. Place marbles of equal diameter around the edge. The marbles should fit in the groove between the outer edge and the raised circular impression. Place an identical can on top of the marbles so it rotates fully. Have students place heavy objects in the can and feel how easily the can turns. Discuss the use of ball bearings and roller bearings in roller skates, bicycles, wagons, automobiles, and other machinery. Have students use reference books and other media to learn more about the design and use of machinery.

# 3. Have a small group of students investigate lubricating materials sold in hardware stores and automobile supply stores. Let them interview people who work in these stores and report their findings to the class. Some special lubricants they may investigate are penetrating oil, dry lubricants, graphite, grease, grades and types of crankcase oil, and ski wax.

Instructional Objective

Given appropriate objects, demonstrate potential energy.

Concept

Potential energy

Materials needed:

- ruler
- rubber band
- spring
- ball or rock
- balloon
- dry cell
- match

Learning activity:

Show students a ruler. Ask them if it can move anything. Bend it and ask again. Discuss "potential energy." Have students demonstrate potential energy using a rubber band, a spring, or other elastic objects. Hold a ball or other small object above the floor. Ask students if it has potential energy.

Use a match and a dry cell to demonstrate the potential energy in chemical and electrical systems.

Instructional Objective

Given appropriate materials, identify the variables that effect the energy of moving objects.

Concept

Kinetic energy

Materials needed:

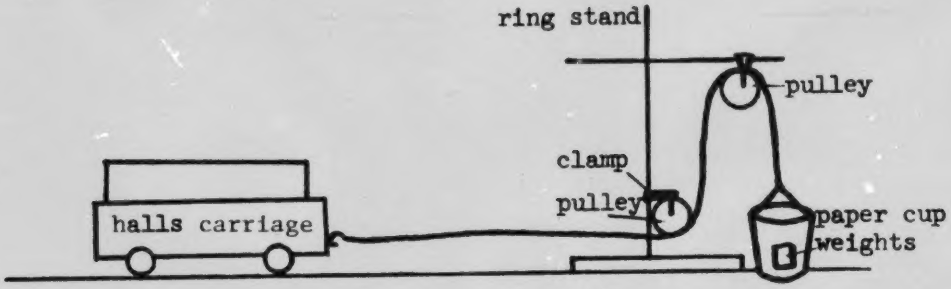
- marbles
- sand
- boxes
- weights
- paper cup
- golf balls
- single pulley
- billiard or croquet balls
- ping pong balls
- ring stand with ring
- rope or twine
- halls carriage

Learning activities:

1. Set up an apparatus like the one in the following picture and have students do the following:
   Place a 500 gm weight in the carriage and enough weight in the cup to move the carriage. Predict what will happen to the speed of the carriage if twice as much weight is put into the cup. Check the prediction by

putting twice as much weight into the cup.

Predict what will happen to the motion of the carriage if you put 1,000 gm in it? Check your prediction by actually doing this.



2. Prepare a track by nailing two strips of wood about two centimeters apart, on a wooden board about 80 centimeters long. Prop one end of the board about 15 centimeters high to make a ramp.

   Have students explore the behavior of rolling spheres as follows:

   a. Roll a marble, golf ball, or other sphere down a ramp so that it collides with an identical sphere. Roll one sphere down a ramp so that it collides with two identical spheres. Then try three spheres and four spheres.

      Compare the speed of the target spheres and the distance they travel in each instance.

   b. Roll two spheres down the ramp so they collide with one, two, three, and four identical spheres. Compare the resulting speed of the target spheres and the distance they travel in each instance.

   c. If a sphere of greater mass than the target sphere is used, predict the result of the collision. Experiment colliding spheres of different masses and try to determine the relationship between the masses of the spheres and the speed of the target spheres.

   d. Make sliders out of small boxes filled with sand. Roll marbles, bearings, and golf balls down the ramp so they collide with the slider. Compare the forces of the various rolling balls by measuring the distances the slider moves and identify the variables that determine the strength of the impact.

3. Discuss "kinetic energy" and help students determine the variables that affect the energy of a moving object. Ask the following questions to stimulate and direct discussion. "How does the speed of a moving object affect its impact? How does the mass of a moving object affect its impact? How can the impact of objects be measured and compared?"

Instructional Objective	Concept
Given an object, move it and determine the amount of work done.	Work

Materials needed:

- cuisenaire rods
- plastic centimeter cubes
- spring balance
- metric ruler
- yardstick or measuring tape

Learning activities:

1. Distribute cuisenaire rods or plastic centimeter cubes. Assume the weight of a white rod or one centimeter cube to be one gram. Have students lift a one gram weight first one centimeter, then two centimeters, then three centimeters. Define the one centimeter gram of work and ask students to determine how much work is done when lifting one gram to two centimeters, and three centimeters.

   Have them lift various rods or various numbers of cubes to various heights and record the information on a data sheet. Remind students that when they are lifting, they are overcoming the resistance of gravity; therefore, it takes one gram of force to lift a one gram weight. Technically, force should be reported in Newtons but in general usage it is reported in grams.

Force in Grams	Distance in Centimeters	Work in Centimeter Grams

2. Define a foot - pound and have students calculate how many foot - pounds of work they do when they climb a particular flight of stairs.

3. Have students slide objects across a table or the floor, measure the force used with a spring balance, measure the

distance and calculate the work done.

4. Have students push against a wall for about 15 seconds and ask them how much work they have done.

Instructional Objective

Given a simple machine, compare its work output with the work put into it.

Concepts

Simple machine
Work
Conservation of energy

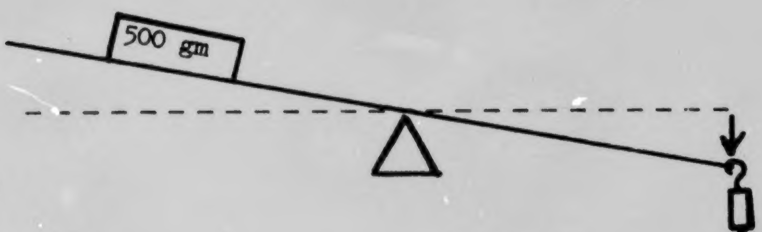
Materials needed:

- meter stick
- metric ruler
- triangular prism (wooden, for fulcrum)
- metric weights
- pulleys: single and double
- pulley support
- window shade cord
- spring balance
- sound films about simple machines

Learning activities:

1. Have students make levers using meter sticks as lever arms and wooden prisms or blocks for fulcrums. Tell them to keep the fulcrums at the center of the meter stick to prevent the weight of the meter stick from affecting the experiment. Have students measure the force exerted (with a spring balance), the distance the force is applied, and calculate the work done. Identify this as work input. Have them measure the distance the weight is raised and calculate the work done on the weight. This is work output. Help them compare the work output to the work input. Ask, "Are the two calculations equal? Should they be equal? If they are not equal, what other force is involved?"

   Example:



Output	Input
Distance x Weight = Work	Distance x Force = Work
1 cm x 500 g = 500 cm g	4 cm x 130 gm = 520 cm g

2. Have students compare work output with work input using a variety of pulley systems. Instruct them to pull slowly and evenly and read the spring balance when the force is

moving at a constant speed. Weights of one to four kilograms are appropriate for work with pulleys. The pulley systems in the next investigation suggest ways to arrange pulleys.

3. Have students study the calculations in the activities above and look for patterns. Discuss "conservation of energy" and use the calculations to illustrate it. Help students understand how machines trade distance for force, and force for distance.

Instructional Objective	Concept
Given a simple machine, calculate its mechanical advantage.	Mechanical advantage

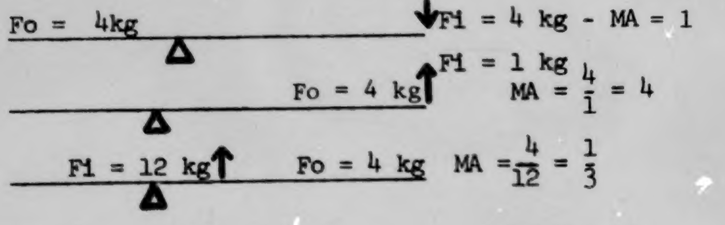
Materials needed:

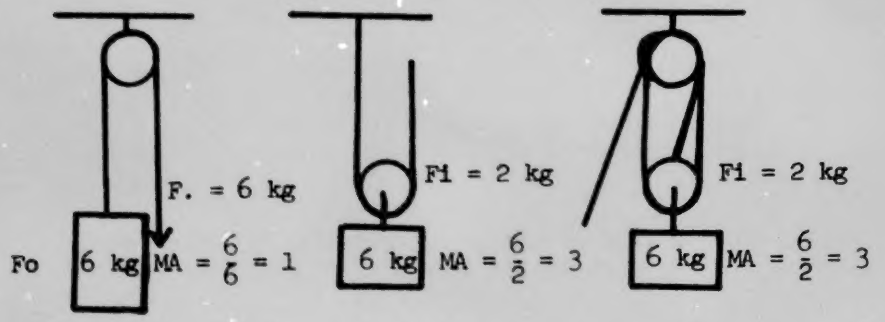
- levers
- pulleys
- weights
- spring balances
- meter sticks

Learning activities:

1. As students lift objects weighing 4 kg or more with levers and pulley systems, have them find the ratio between the force input and the force output. Discuss the meaning of "mechanical advantage." Have students calculate the mechanical advantage of machines similar to those pictured below. The calculations do not allow for friction or any other outside force.

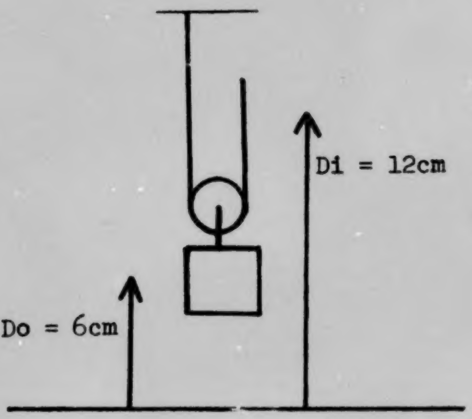
$$\text{Mechanical Advantage (MA)} = \frac{\text{Force output (Fo)}}{\text{Force input (Fi)}}$$





2. Have students also determine mechanical advantage by calculating the ratio between the distance the force is applied (Di) to the distance the weight is lifted (Do).

$$MA = \frac{Do}{Di}$$



$$MA = \frac{12}{6} = 2$$

Instructional Objective	Concepts
Given a collection of simple machines, classify them by type.	Simple machine Lever Pulley Inclined plane Wheel and axle Wedge

Materials needed:

simple machine collection, examples:
inclined plane, screwdriver, scissors, egg beater, nail file, nail clipper, key, doorknob, screw, jar lid, knife, saw, chisel

Learning activities:

1. Make a class collection of tools, machines, and other devices. Have students classify each object as a specific type of simple machine. Let them list names of each object on a chart like the one on the following page. Some items may be listed under two or more machines, for example, a pair of scissors would be classified under both lever and wedge. Any wedge or screw could also be classified as an inclined plane. Let students also classify machines they identify at home, at school, and any place else in their community.

2. Have students make finer distinctions such as: classifying lever as class 1, class 2, or class 3; identifying pulleys as fixed, movable, single, double, and triple; and identifying whether in a specific wheel and axle machine, the wheel turns the axle or the axle turns the wheel.

# 3. Have students identify parts of large machines as simple machines. A field trip to an industrial plant or to a construction site should offer many opportunities to observe and identify machines.

# 4. Invite a craftsman to class to discuss the tools used in his or her trade.

Lever	Pulley	Wheel and Axle	Inclined Plane	Screw	Wedge
pliers scissors pump handle hammer tin snips wire cutters	block and tackle window shade pulley fence stretcher	steering wheel handle bars ice cream freezer wench pencil sharpener egg beater bicycle	house roof driveway ramp stairs playground slide	jar lid wood screw bolt nut propeller electric fan	knife chisel saw axe blade pencil sharpener scissors tin snips

Instructional Objective

Given a machine, identify the energy source and energy receiver and trace the transfer of energy throughout its operation.

Concepts

Energy source
Energy receiver
Energy transfer

Materials needed:

machines: wind up toys, toy cars, food grinder, etc.
simple machines: can opener, hammer, saw, scissors
bicycle

Learning activities:

1. Have students bring machines from home. Have them demonstrate the use of the machines. Ask them to identify the force used to make it operate. Introduce the terms energy source and energy receiver. Have children identify the energy source and the energy receiver for each machine. Have students trace the transfer of energy as the machine is used.

2. Have a student bring a bicycle to class. Turn the bicycle upside down and turn pedals slowly with your hands. Have students trace the transfer of energy from hands to rear wheels

Instructional Objective

Given appropriate materials, construct or assemble a machine.

Concept

Machine

Materials needed:

reference books
assorted materials

Learning activity:

# 1. Have students use reference books to find directions for constructing different machines. Let them obtain their own materials, construct the machines, and demonstrate them to the class. Some suggested machines are water wheel, windmill, steam turbine, pulley system, windlass, catapult, equal arm balance, spring balance, and inertial balance.

Instructional Objective	Concept
Given access to the community, investigate and identify the use of machinery in the community.	Machinery

Materials needed:

access to the community

Learning activities:

# 1. Take children for a walk in the community or the school. Have them list all the machines they see. Make a class chart showing the name of the machine, its use, and who uses it.

Machine	Use	Who
hammer	pound, pry	carpenter, people
bus	land transportation	bus driver
lawn mower	cut	mother, father, student

# 2. Invite a carpenter, factory worker, custodian, butcher, jeweler, piano tuner, or other worker, to visit the class to demonstrate the use of tools in his work.

Have students interview neighbors and other people to identify their use of tools.

# 3. Visit a factory to observe the machines used and the division of labor on an assembly line. Have students identify companies in Cincinnati that make machine tools.

Instructional Objective	Concept
Given reference materials, describe the contribution of scientists and inventors in the areas of force, motion, and machines.	Contributions to science and technology

Materials needed:

reference materials

Learning activity:

Have students research and report to the class the contributions made by scientists and inventors in the area of machines. Some suggested names to use are: Leonardo Da Vinci, Galileo Galilei, Thomas Jefferson, Jan Matzeleger, Cyrus McCormick, Eli Whitney, and Granville T. Woods.

Make a bulletin board or mural showing results of the childrens' research.

Visit the Greater Cincinnati Airport to see the murals depicting man and machines in the development of the community.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

726	Action and Reaction
2069	Energy
66	Energy and Work
7	Forces
1881	Inclined Planes
714	Laws of Motion
1882	Levers
2300	Machines Do Work
2039	Machines That Move the Earth
945	Motion
59	Moving Things On Land
1880	Pulleys
717	Pulleys and Work
408	Simple Machines at Sea
2092	We Use Power
1879	Wheels and Axles

Filmstrips

6605	Friction At Work
7363	Fundamentals of Science: Simple Machines
6110	How Man Uses Fuels
6677	Inclined Planes At Work (Work, Friction and Machines)
7749	An Introduction to Simple Machines (Introduction to Matter and Energy)
6678	Levers at Work (Work, Friction and Machines)
6679	Pulleys at Work (Work, Friction and Machines)
6681	Screws and Wedges at Work (Work, Friction and Machines)
6680	Wheels and Axles at Work (Work, Friction and Machines)
6676	Work and Friction (Work, Friction and Machines)
7758	The Work of Gears (The Work of Simple Machines)
7757	The Work of the Inclined Plane, Screw and Wedge (The Work of the Simple Machines)
7755	The Work of the Lever (The Work of Simple Machines)
7756	The Work of the Pulley (The Work of Simple Machines)
7754	The Work of the Wheel and Axle (The Work of Simple Machines)
6749	World's Energy Supply

A-V Media Approved for Purchase

Filmstrips

Jam Handy Filmstrips

Work, Friction and Machines

- Work and Friction
- Inclined Planes at Work
- Levers at Work
- Pulleys at Work
- Wheels and Axles at Work
- Screws and Wedges at Work

Society for Visual Education, Inc.

The Work of Simple Machines (Filmstrips/Recording)

- The Work of the Wheel and Axle
- The Work of the Lever
- The Work of the Pulley
- The Work of the Inclined Plane, Screw and Wedge
- The Work of the Gears

Study Prints

Encyclopedia Britannica Educational Corporation

5920 Simple Machines

MAGNETISM

Background

Magnets and Their Properties. Certain objects, called magnets, possess a force that attracts objects made of iron, nickel, or cobalt. Surrounding a magnet is a magnetic field. The field can be thought of as imaginary lines curving from one pole to the other. The magnetic force is strongest at the poles where the lines are closer together and weakest further away from the poles where the lines are farther apart.

The ends of the magnets are called poles. The poles on opposite ends of a bar magnet are different from one another. If unlike poles of two magnets are brought together they will attract each other. However, two like poles will repel one another.

The earth is a magnet. It, too, is surrounded by a magnetic field. Its magnetic poles are near the geographic poles. If a bar magnet is suspended by a string at its center, one end will point toward the north magnetic pole. This end is called the north pole of the magnet. The other end, called the south pole of the magnet, will point toward the earth's south magnetic pole.

The difference between magnetic north and true north is called the angle of declination. In Cincinnati, the magnetic north pole is in line with the geographic north pole so the angle of declination is zero degrees.

Types of Magnets. There are basically three types of magnets: permanent magnets, temporary magnets, and electromagnets. There is one magnetic material found naturally. It is an iron ore called "magnetite."

Permanent Magnets. The most common magnets are objects of metal that attract other metallic objects. These are called permanent magnets. Permanent magnets are made of steel, mixtures of iron, nickel, and cobalt, or mixtures of aluminum, nickel, and cobalt (alnico magnets). Some permanent magnets are made of metals combined with oxygen. These are called ceramic magnets or ferrites. Permanent magnets are made by moving another magnet across the metallic material repeatedly, by passing an electric current through a wire coil near the materials, and by hammering the material in a magnetic field. Permanent magnets can become demagnetized if they are heated or if they are hit very hard.

Permanent magnets are made in different shapes depending upon their intended uses. There are bar magnets, cylindrical magnets, horseshoe magnets, disc magnets, circular magnets, and magnetic strips.

Temporary Magnets. When an object, such as a nail, is in contact with a permanent magnet it also becomes a magnet. When it is no longer in contact with the magnet it is no longer magnetic. Thus, it is called a temporary magnet.

Electromagnets. A coil of wire has magnetic properties when an electric current flows through it. It is called an electromagnet. One end of the electromagnet is the north pole and the other end is the south pole. If the direction of the current is reversed, the poles are reversed. When the current is shut off the magnetic force stops.

Uses of Magnets. Permanent magnets are used to support objects on metal surfaces and to fasten doors on cabinets and refrigerators. They are used in magnetic compasses, speaker systems, small motors, computers, and other electronic devices.

Electromagnets are useful because they can turned on and off. They also can be made stronger than permanent magnets. They are used to load heavy metal objects into railroad cars. They are used widely in electric motors and in electronics. Vibrators made with electromagnets can remove dirt from watches and other delicate mechanisms. They can also be used to cut hard substances. Electromagnets can be made to operate electric switches. Any application of electricity that produces motion involves some use of an electromagnet.

Magnetic Models. The magnetic effect caused by electricity flowing through a coil of wire has lead scientists to an understanding of how magnets work. Electric current is a permanent part of a permanent magnet. The molecules line up in the same direction the metals become magnetized. This idea is called the molecular model of magnetism.

The electron model provides a better explanation of magnetism. Electrons are negatively charged particles that revolve around the nucleus of an atom. They also rotate. Their motions produce electric currents. Each electric current is surrounded by a magnetic field. In the atoms of most elements, the electrons spin in different directions so their magnetic fields cancel each other. In unmagnetized iron the electrons spin in opposing directions. In magnetized iron, most of the electrons spin in the same direction. Their magnetic fields reinforce one another and produce one large magnetic field.

Rationale

The unit Magnetism is designed to help children (1) explore the variety, properties, and uses of magnets and (2) begin to use molecular and electron models to explain magnetism.

Magnetism is an important natural force that has many domestic and industrial applications. Magnetism has an important relationship to electricity. Children are intrigued by magnets and magnetic effects.

Glossary of Concepts

Magnet	An object that attracts iron, cobalt, or nickel.
Attract	To pull together.
Repel	To push apart.
Permanent Magnet	An object that is a magnet independent from another magnet or an electric current.
Temporary Magnet	An object that is magnetized only when in contact with a magnet.
Magnetic Force	The push or pull of a magnet.
Magnetic Field	The area of force around a magnet.
Polarity	The concentration of force around the ends of a magnet.
Magnetic Compass	A freely turning magnet that interacts with the earth's magnetic field to indicate direction.
Declination	The difference between magnetic north and true north.
Inclination	The angle at which the earth's magnetic lines of force strike the earth.
Electromagnet	Magnetism produced by electric current.
Molecular Model	An explanation of magnetism in terms of the polarity of molecular arrangement.
Electron Model	An explanation of magnetism in terms of the direction of electron rotation.

Investigations

Instructional Objective

Given appropriate materials, identify the properties of magnets.

Concepts

Magnet
Attract
Repel
Permanent magnet
Temporary magnet
Magnetic shield

Materials needed:

- magnets
- objects made of iron or steel
- other metallic and non-metallic objects

Learning activities:

1. Provide students with magnets and an object collection. Have them describe the interaction of the magnet with each object. Introduce the word "attract." Define it and discuss it. Have the students classify objects into two groups, objects that magnets attract and objects that magnets will not attract. Let them test many objects and materials to determine whether or not they are attracted by magnets.

2. Have students give criteria that distinguish magnets from other objects. Ask,"If two objects are drawn together when brought close to one another, how can you tell which one is the magnet?"

   Let students explore the interaction of two magnets with one another. Introduce the word "repel" and discuss it.

   Help students identify the conditions under which magnets attract one another and the conditions under which they repel. Introduce and discuss "permanent" and "temporary" magnets.

3. Make magnetic mystery boxes. Collect four small boxes 2 to 4 cm deep. In each box place one of the following: an aluminum object, an iron object, a non-metallic object, and a magnet. Seal and number each of the boxes. Put the boxes in a interest center along with a good bar magnet. Let students use the magnet and try to identify each type of object.

4. Have students place a variety of materials between two magnets or between a magnet and a paper clip. Have them identify materials that the magnetic force will penetrate and those that weaken or absorb the magnetic force.

Instructional Objective	Concept
Given a magnet, measure its force.	Magnetic force

Materials needed:

magnets
paper clips
metric ruler

Learning activity:

Provide each student with a magnet and the other materials above. Ask them to measure the strength of their magnet is some way. Let them compare the relative strength of various magnets.

One method is to count the number of paper clips the magnet will pick up. Another method is to measure the farthest distance (in millimeters) from which the magnet will attract a paper clip.

Instructional Objective

Given a magnet, map its magnetic field.

Concepts

Magnetic field
Polarity

Materials needed:

- permanent magnets
- iron filings
- magnetic compasses
- paper
- hairspray
- pencils

Learning activities:

1. Have groups of three students use the following directions to make maps of magnetic fields.

    > Place a magnet on a large sheet of wrapping paper (approximately 1 meter long). Place a compass at the north pole of a magnet. Make a dot, with a pencil, at the north pole of the compass needle. Move the compass so that the dot is at the south end of the compass. Continue to make dots until the compass needle no longer reacts, the line runs off the paper, or the line of force returns to the magnet. Connect the dots in a smooth curve. Repeat by beginning at a different point on the north pole. Display the results on a bulletin board.

    Introduce and discuss the concept of "magnetic field."

2. Provide students with a magnet, some iron filings, and a piece of paper. Direct the students to place the magnet under the paper and sprinkle the iron filings gently on the paper so the lines of magnetic force are clearly visible. Spray hair spray on the filings, let dry, and the filings will stick to the paper. Cover with transparent contact paper for a permanent display.

3. Let students make iron filing maps similar to number two above, but use two interacting magnets. Have them place two magnets end to end, but not touching. Make one map with north pole to north pole and another map with south pole to north pole. Have them compare the two maps with one another and with the map in number two, above.

4. Provide students with a variety of magnets. Have them find the poles of each magnet. Rubberized magnets, magnetic strips, and disc magnets have poles that are not on the ends, like bar and horseshoe magnets. Let students use magnetic compasses, other magnets, and iron filings to devise their own methods of finding the poles. Introduce and use the word "polarity."

Instructional Objective

Concept

Given appropriate materials, make a magnetic compass.

Magnetic compass

Materials needed:

needles
strong magnet
thread
cork
small dish

Learning activities:

1. Suspend a strong bar magnet by a thread. Ask, "Which way does it point? Does it always point the same direction? What does the "N" and "S" on the magnet really mean? What causes it to point in a specific direction?"

2. Magnetize a needle by stroking it in one direction from one end to the other with the south pole of a strong magnet. Stroke at least 50 times. Test the ends of the needle with a compass.

   Tie a piece of fine thread at the center of the needle and suspend it from a support or place the needle on a thin piece of cork and float it in a dish of water.

Instructional Objective

Concepts

Given a magnetic compass, use it to determine direction.

Magnetic compass
Declination
Inclination

Materials needed:

magnetic compasses
treasure hunt directions
paper and art supplies

Learning activities:

1. Provide students with magnetic compasses. Give them experience in finding various directions. Name some objects and have them give the direction of the objects from where they are. Give them a direction and have them name an object they see in that direction.

2. Take students outdoors on a treasure hunt. Give them a set of directions to a series of identifiable landmarks. Include the number of degrees and a distance (in meters, or paces) for each landmark. At the end of the hunt provide a treat as the treasure. This is a good activity for a camp, park, or outdoor recreation center.

3. Have students use encyclopaedias and other reference books to learn about declination and inclination. Have them define the terms and find out how they are measured.

#4. Have students make a bulletin board display showing uses of magnetic compasses. Illustrate uses of magnetic compasses in various occupations.

Instructional Objective	Concepts
Given appropriate materials, make an electromagnet and identify the variables that affect the strength of an electromagnet.	Electromagnet Variables Permanent magnet

Materials needed:

insulated copper wire
nail
dry cells
paper clips or other objects made of steel

Learning activities:

1. Provide the following set of directions and have students make electromagnets.

   Wind a piece of wire around a nail twenty or more times. Allow about 10 cm on each end to place on dry cell terminals. Connect the ends of the wires to the dry cell and pick up paper clips and other objects.

2. Have students measure the strength of the magnet they made by counting the number of paper clips it will support. Tell them to make an electromagnet that will pick up more paper clips. They may join together several dry cells, change the metal core, or increase the number of coils.

3. Have students pick up various objects with the electromagnet. Ask, "How is an electromagnet like a permanent magnet? How is it different? What advantages does an electromagnet have? What advantages does a permanent magnet have?"

Instructional Objective	Concepts
Given reference materials, describe how the molecular and electron models are used to explain magnetism.	Molecular model Electron model

Materials needed:

reference books and other media
art supplies

Learning activity:

Ask students to explain how they think magnetism works. Let them view filmstrips and use reference books to find out how scientists explain magnetism. Discuss the molecular and electron models and their use in understanding and explaining magnetism. Let students draw diagrams to illustrate how these models explain magnetism.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

1985	Electromagnets
145	Magnetic, Electric and Gravitational Fields
1657	Magnets
860	Magnets and Their Uses

Filmstrips

6480	Electric Magnets
7471	Electricity and Magnetism
5998	Magnetic Fields
6481	Permanent Magnets
5997	What is Magnetism?
6174	What is Magnetism?

A-V Media Approved for Purchase

Filmstrips

Jam Handy

Magnets (2 Filmstrips)

Magnetic Fields
What is Magnetism?

Transparencies

Popular Science

Magnetism and Electricity (7 Transparencies/11 Overlays)

ELECTRICITY

Background

Electricity is a versatile and useful form of energy. It can be used to produce heat, light, magnetism, motion, and chemical changes. It can transmit and reproduce sound. It can be transmitted and distributed in varying amounts to almost any place. It can be stored in batteris and be ready for use on demand.

The Electron Model. All matter is electrical in nature. Atoms consist of nuclei positively charged with electrons revolving in orbits around them. The electron's shells in the outer orbits of metals are easily removed or given up. When they are removed, the atom becomes positively charged and will readily receive or attract another electron. A source of electricity keeps pumping electrons into the conductor. This is passed on to succeeding atoms and is used by an electrical device, such as, a light bulb, a television set, or an electric motor. The current of electrons then flows back to the energy source. The energy is not used up nor destroyed, but is changed into some other form, such as, light, heat, magnetism, or motion.

Resistance to the electric current produces heat. If the resistance is great enough, the conductor becomes hot enough to glow and produce light. Electricity flowing through wires produces a magnetic force. This magnetic force produces motion in electric vibrators, motors, and solenoids. Motors are generators in reverse. In a motor, electricity produces rotary motion. In a generator, rotary motion produces electricity.

Static Electricity. The interaction between two bodies, at least one of which is electrically charged, is called static electricity. It is electricity at rest rather than electricity in motion. Static electricity is produced by rubbing two dissimilar objects together. When a rubber balloon is rubbed with wool, the atoms in the wool lose some of their electrons and the atoms in the balloon gain them. This produces a positive charge in the wool and a negative charge in the balloon. Since unlike charges attract one another, the balloon will then stick to the wool. It will also attract a neutral object, such as, curtains, or a wall. Like charges will repel. Two balloons, negatively charged, will repel one another.

Lightning is produced by static electricity. A hugh spark is produced when electricity is discharged between two clouds, or between clouds and the ground.

Current Electricity. The electrons in the outer shell of the atoms of metals are free to move from one atom to another. This makes it possible for metals to conduct electricity in non-metallic materials, such as, rubber, cotton, and glass. The electrons are held so tightly by the atoms that they cannot move. These are called non-conductors and are used to insulate electric wires.

The electrons move at a speed of a few inches per second, but the electrical energy moves at the speed of light, over 186,000 miles per second. A metal wire works much like a garden hose full of water. When the water is turned on, at one end, water comes out the other end almost instantly, although the water in the hose may have moved only a few inches.

There are two kinds of current, direct and alternating current. Direct current moves in one direction only. Alternating current moves, alternately back and forth, several times a second. Most house current is 60 cycle (60 Hertz), that is, the direction of the current moves back and forth 60 times per second. Automobiles, trolley buses, and electric locomotives use direct current.

Production of Electricity. Electric batteries produce electricity by chemical action. In an automobile battery, the interaction of lead oxide plates with sulfuric acid produces electricity. Dry cells are dry on the outside only. Inside a paste consisting of ammonium chloride and manganese oxide is found. These materials interact with a carbon rod, in the center of the cell, and the zinc case to produce electricity.

Most electricity is produced by electric generators. To understand how generators work it is necessary to know something about the interrelationship of magnetism and electricity. Electricity flowing through a wire produces a magnetic effect. Conversely, a magnet moving inside a coil of wire produces an electric current. An electric generator usually consists of powerful magnets that are whirled inside coils of copper bars. However, some generators whirl coils of copper wire inside a powerful magnet. Water wheels, steam turbines, and gasoline engines are used to turn the magnets on the coils. Electric generators are of two types--those that produce direct current and those that produce alternating current.

Small amounts of electricity can be produced by other means. A thermocouple is a device made of two wires of different metals fastened tightly at both ends. When one end is heated, a small electric current is produced. A photo-electric cell changes light into electricity. Solar batteries are photo-electric cells used to supply electricity in space vehicles and satellites.

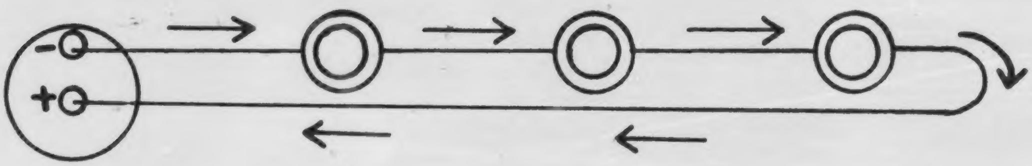
Transmission of Electricity. Electricity travels through electric circuits. Electric circuits are systems of metal wires that transmit electric current from the energy source--the battery or generator--through an energy receiver and back to the energy source. One wire conducts the electricity from the source of electricity to the energy receiver. The other wire conducts the electricity from the energy receiver back to the energy source. Electricity flows from the negative terminal of the battery or generator to the positive terminal.

When the circuit is broken, the flow of electricity stops. Switches are used to open and close circuits. Most circuits are designed to carry limited amounts of electric current. Fuses and circuit breakers are safety devices that overheat and break the circuit when there is an overload of current. Transformers are used to increase and decrease the voltage of alternating currents.

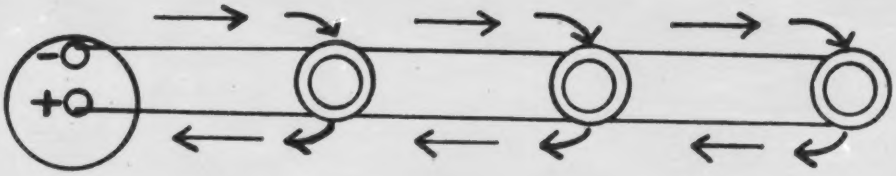
Series and Parallel Circuits. Two or more electric devices may be attached to the same energy source in series or parallel circuits. In a series circuit, the electrical devices are connected by a single wire. The electricity must flow through one device to get to the next one. If one becomes defective, loose, or disconnected, the others will not work.

In a parallel circuit, the current is divided so that some of it goes through the device and back to the source while some of it goes on to the next device.

SERIES CIRCUIT



PARALLEL CIRCUIT



Rationale

The unit Electricity is designed to help students (1) observe and describe the properties and effects of static and current electricity, (2) construct electrical circuits and other devices, (3) begin to understand how electricity is produced and transmitted, and (4) appreciate the usefulness and flexibility of electricity as a source of energy.

Modern industrial societies are very dependent upon electricity as a source of energy. Some application of electric power is made in almost every human activity. The history of electricity and all the technology related to it are a good example of the growth and development of scientific knowledge. The study of electricity provides many opportunities for individual and group involvement in direct, firsthand science experiences.

Glossary of Concepts

Static Electricity	The electricity of stationary charges produced by rubbing unlike bodies.

Static Charge	An accumulation of electrical energy on an object; an imbalance of positive and negative charges.
Attract	To pull toward; to draw together.
Repel	To push away.
Positive Charge	The type of charge possessed by protons; the opposite of negative charge.
Negative Charge	The type of charge possessed by electrons; the opposite of positive charge.
Complete Electric Circuit	An uninterrupted path of conductors and electrical devices connected to two terminals of an energy source.
Neutral	No charge; the balance of positive and negative charges.
Conductor	A material through which electricity can flow.
Non-Conductor	A material through which electricity cannot flow.
Insulator	A non-conductor used to cover a conductor or separate it from other conductors.
Energy Transfer	The process of moving energy from one object or system to another object or system.
Galvanometer	An instrument for detecting small electric currents.
Series Circuit	An electric circuit in which the electricity flows through one energy receiver to another energy receiver before returning to the energy source.
Parallel Circuit	A circuit that divides the current so that part of it passes through an energy receiver and returns to the energy source and part of it passes on to the next energy receiver.
Electric Current	The flow of electrical energy through a conductor; the movement of electrons from one atom to another.
Energy Source	A system that produces and supplies energy to other objects and systems.
Energy Receiver	An object or system that receives energy; an electrical device.
Energy Chain	A series of energy transfers.
Voltaic Cell	A system of metal plates and a chemical solution that produces an electric current.
Dry Cell	A sealed power source that produces electricity by chemical interaction.

Battery	A system of two or more electric power cells.
Electric Generator	A system that produces electricity by whirling powerful magnets inside coils of copper wire or bars.

Investigations

Instructional Objective

Given appropriate materials, describe evidence of static electricity and distinguish between positive and negative charges.

Concepts

Static electricity
Static charge
Attract
Repel
Positive
Negative
Neutral

Materials needed:

combs
object collection: balloons, glass rods, hard plastic, feathers, plastic bags, hard rubber, wool, silk, nylon, yarn
aluminum pie pan
rubber bands

Learning activities:

1. Have students comb their hair and put the combs near small bits of paper. Have them observe the paper for a while and see what happens.

   Discuss "static electricity" and "static charge." Use the words "attract" and "repel" to describe the interaction.

2. Have students rub inflated balloons on their hair and observe the interaction between balloons and hair, and between two different balloons. Tell them that the balloons have a negative charge and the hair a positive charge. Let them rub various materials together, determine the charges of each object, and describe the interaction between any two objects. Use the word "neutral" to describe objects with no charge.

3. Put a plastic bag, aluminum pan, and two rubber bands in an interest center. Provide the following set of directions.

   Place the plastic bag on a table and rub it hard with the piece of wool. Stretch the two rubber bands at right angles across an aluminum pan. Lift the pan by the rubber bands. Lift the plastic bag by pulling up on one edge and hold it against the pan. Touch a finger to the edge of the pan. Pull the plastic bag off the pan and touch the pan to your nose. Describe what happens.

Instructional Objective | Concept

Given appropriate materials, construct a complete electric circuit.

Complete electric circuit

Materials needed:

size D dry cells
miniature light bulbs, $1\frac{1}{2}$ - 3 volts
bell wire
electric buzzer and/or bell

Learning activity:

Have students use a battery, a bulb, and a wire and try to make the bulb light. Let them do this in as many ways as they can. Let them make buzzers and bells work also. Have students draw diagrams of the various ways they assembled the materials and try to analyze why some arrangements worked and others did not. Discuss the concept of a "complete electric circuit."

Instructional Objective | Concepts

Given a collection of materials, classify them as conductors and non-conductors.

Conductor
Non-Conductor
Insulator

Materials needed:

miniature light bulbs
copper wire
miniature receptacle
masking tape
object collection: foil, nail, paper clip, pencil, paper, plastic, copper wire, coins
knife-blade switch

Learning activities:

1. Have small groups of students construct a circuit including a bulb (in a receptacle), a knife-blade switch, and a dry cell. Instruct them to place objects across the switch terminals. Have them place the objects that make the bulb light in one pile and those that do not in another pile. Identify the first pile as conductors and the second pile as non-conductors.

2. Let interested students devise a method for testing the ability of liquids to conduct electricity. They should try distilled water and salt water solutions of different concentrations. Attach a copper strip to one wire and a zinc strip to the other. Insert these into the liquid. The plates are called electrodes.

3. Have students make a class collection of electric materials, devices, and old appliances. Help them observe the materials and identify the parts of the materials that are conductors and the parts that are non-conductors. Introduce the concept of an "insulator." Have students find examples of insulators and make a list of them. Encourage them to add items to the list as they come across examples in the school, at home, and outdoors.

4. Have students compare the properties of conductors and non-conductors. Ask, "What kinds of materials conduct electricity? What kinds of materials will not conduct electricity?"

Instructional Objective	Concepts
Given appropriate materials, demonstrate how electricity produces heat, light, magnetism, and motion.	Energy transfer Electric interaction

Materials needed:

different kinds of wire: copper, iron, aluminum, nichrome
$1\frac{1}{2}$ volt dry cells
miniature light bulbs in receptacles
paper clips
aluminum pans
pencils

Learning activities:

1. Have students attach different kinds of wires to both terminals of a $1\frac{1}{2}$ volt dry cell and feel them cautiously. Ask, "What is the evidence of electric interaction in this activity?"

   Have them rank the wires in order of their temperature - from coolest to warmest. Have them construct complete circuits using light bulbs and different kinds of wire. Ask, "Do all the wires burn with the same intensity? Is there a relationship between the temperature of the wire and the brightness of the bulb?"

2. Have students try to make light bulbs as follows:

   > Wrap a piece of nichrome wire around a piece of clothes hanger wire to form a coil about $1\frac{1}{2}$ cm long. Leave enough wire on each end to attach the coil to copper wire. Attach the copper wire to two or three $1\frac{1}{2}$ volt dry cells. The coil should glow.

3. Have students make electromagnets by wrapping insulated copper wire around large nails and attach them to a dry cell.

4. Have a small group of students use electricity to produce rotary motion in the following way.

Clip the edge off a small aluminum pan with a pair of scissors. Slip six paper clips on to the side of the pan. Distribute them evenly around the pan. Make a small indentation in the center of the pan and balance it on the point of a pencil. Fasten one terminal of an electromagnet to one terminal of a dry cell. Tape the other terminal of the electronmagnet to the other terminal of the dry cell intermittently. Hold one end of the magnet close to one of the paper clips. Synchronize the tapping to make the pan rotate.

5. Have students make lists of electrical devices and appliances used at school, at home, and in industry and indicate the evidence of electric interaction for each item.

Instructional Objective	Concept
Given appropriate materials, construct a simple galvanometer.	Galvanometer

Materials needed:

glass jar
bell wire
dry cell
thread
sewing needle
magnet
masking tape

Learning activity:

Have a small group of students make a simple galvanometer as follows:

Wrap insulated copper wire around a small glass jar about 50 times. Remove the wire from the jar and wrap it with masking tape. Leave 20 to 30 cm of wire on each end of the coils. Magnetize a sewing needle by stroking it in one direction with one pole of a strong magnet. Suspend the needle with thread so it hangs at the center of the coil. Attach both ends of the wire to a dry cell or other low voltage electric current. There should be a noticeable deflection in the needle. Discuss the design and use of a galvanometer.

Instructional Objective	Concepts
Given two or more light bulbs, construct series and parallel circuits and compare the properties of each.	Series circuit Parallel circuit

Materials needed:

dry cells
bell wire
miniature light bulbs
miniature receptacles

Learning activities:

1. Instruct students to connect two or more light bulbs in one circuit. Have them use the receptacles. Have them draw diagrams of their circuits. Let students compare the different ways circuits were constructed. Ask, "If one bulb is removed, does the other bulb remain lighted? Does all the electricity pass through one bulb to get to the next?" Introduce "series" and "parallel circuits." Discuss the properties of each. Have students check to see if both types are represented in the circuits they have constructed.

2. Have students compare the brightness of light bulbs in a series circuit to their brightness in a parallel circuit. Have them compare the brightness of a circuit containing one bulb to the brightness of series and parallel circuits containing 2, 3, and 4 bulbs.

Instructional Objective	Concepts
Given complete circuits, trace the electric current.	Complete circuit
	Electric circuit
	Energy transfer
	Energy source
	Energy receiver
	Energy chain

Materials needed:

circuits constructed in previous investigations
aluminum foil, construction paper, masking tape
electrical materials and devices: lamps; small appliances;
electrical toys
clear light bulbs
switches
pictures or diagrams of circuits
reference books and other media

Learning activities:

1. Have students use circuits and diagrams of circuits they made in previous investigations to trace the flow of electricity. Do not be quick to criticize or point out mistakes. Let different students explain their ideas to the class or to small groups. Have them give reasons for their ideas. Let them check their ideas by reading reference books or viewing filmstrips on the subject.

   After they learn that the current flows from the source through the receiver and back to the source, and that electrical energy flows from negative to positive terminals, have students trace the electric current in a clear light bulb, electrical toys, and other electrical systems.

2. Have students make mystery circuits and let one another try to locate it with a circuit tester. A mystery circuit board can be made as follows:

   Fold a piece of construction paper in half. Punch 6 to 8 holes in the paper on one side of the fold.

   Connect two or more holes with strips of aluminum foil. Secure the foil with masking tape. Cover the other holes with foil but do not connect them. Fold the paper so the foil is on the inside. Tape the edges.

   A dry cell, a bulb, and two wires can be used as a circuit tester. Fasten a wire to each terminal of the dry cell. Wrap one wire around the base of the bulb. Place the tip of the bulb over one hold in the circuit board and the other loose wire over another hole. If the holes are connected, the bulb should light.

3. Discuss the terms "energy source" and "energy receiver." Have students identify the energy sources and the energy receivers in a variety of electrical systems. Also, have students describe evidence of interaction in various electrical systems. The interactions will be described in terms of what happens to the energy receiver such as: "The bulb lights. The bell rings. The iron gets hot. The radio plays. The motor runs."

4. Have students trace electric current through a system by making energy chains. For example:

   battery → wire → bulb → switch → battery
   ↘ air

Instructional Objective

Given appropriate materials, demonstrate ways electricity can be produced.

Concepts

Voltaic cell
Dry cell
Battery
Generator

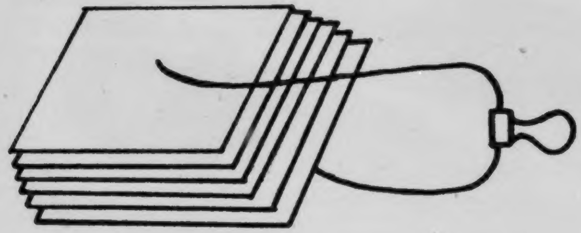
Materials needed:

- zinc sheet
- copper sheet
- vinegar
- salt
- copper wire
- light bulbs
- small electric motors
- blotting paper or paper towels
- pennies
- dimes
- tin snips
- sockets

Learning activities:

1. Have students assemble voltaic cells as follows:

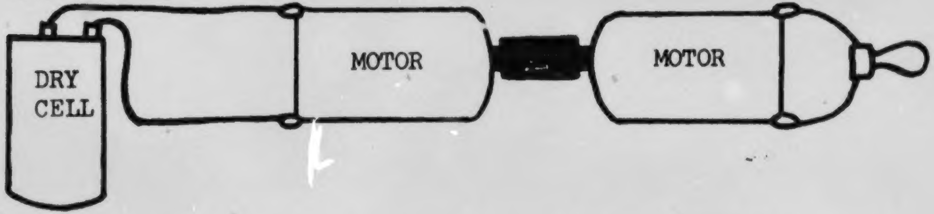
Cut copper and zinc sheets into square 5 cm x 5 cm. Cut squares of blotting paper or paper towel a little larger than the metal square. Soak the paper squares in a solution of salt and vinegar. Make a stack of squares alternating copper and zinc with a piece of the saturated paper between each metal plate. Make certain that the metal plates do not touch and that there are equal numbers of copper and zinc plates. Attach a wire to each side of a receptacle containing a light bulb. Hold or fasten the wire ends to opposite ends of the voltaic pile. The bulb should light.



2. Electric cells can be made by using pennies and dimes in place of the metal plates. Students may try to produce electricity by inserting strips of copper and zinc into a lemon.

3. Ask students to bring in different kinds of used batteries and make a class collection of them. Have them compare the properties of these and note especially the differences in voltage. Use a hack saw to cut open a dry cell and help students identify the parts. Show students an automobile battery. Discuss the differences between a wet cell and a dry cell, and a cell and a battery.

4. Have students place a miniature motor into an electric circuit. Connect the axles of two motors with a piece of plastic insulation from a copper wire or wrap masking tape around them. Attach a light bulb to the second motor. Ask students to describe the energy transfer from the dry cell to the light bulb.



Ask, "What has the second motor become?" Have students use reference materials to find information about electric generators.

Instructional Objective	Concepts
Given appropriate materials, complete an electrical project.	Any or all concepts in this unit

Materials needed:

bell wire
nails
foil
construction paper
felt
miniature bulbs and receptacles
switches
dry cells
reference materials

Learning activity:

Encourage or require each student to complete an individual or small group project. Projects should consist of constructing electrical systems and/or preparing oral or written reports. Use this activity to review any or all concepts in this unit.

Some items students may construct are: a telegraph system, an electric motor, an electric buzzer, a circuit board, a set of mystery circuits, an electric switch, a series circuit, a parallel circuit, a lighting system for a toy house or a model village.

Some suggested topics for reports are: Pioneers in Electricity; Luigi Galvani; George Ohm; Andre Ampire; Hans Oersted; Alessandro Volta; Michael Faraday; Benjamin Franklin; Guglielmo Marconi; Lewis Howard Latimer; Thomas A. Edison; The History of Communication; How Radio Works; How The Telephone Works; How Television Works; Hydroelectric Power; The Search for Energy; Semiconductors, Transistors, and Solar Cells.

Instructional Objective	Concept
Given reference sources, explore careers related to electricity.	Careers

Materials needed:

reference material
resource people
paper and art supplies

Learning activities:

# 1. Have students select a career and tell how electricity is related to it. Have them draw or collect pictures illustrating specific careers in electricity such as: the work of an electrician; electrical engineering; telephone service and television; electronics; appliance repair; and safety engineering.

# 2. Take a field trip to a power station and have students trace the energy transfer from fuel to electricity in homes.

3. Invite an electrician or an electrical engineer to the classroom to discuss his work.

4. Ask the school engineer or custodian to take the class on a tour of the building and discuss the school's electrical system.

5. Have students make a mural showing uses of electricity in the immediate community.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

2417	Electricity: How It Is Generated
434	Electricity: Wires In Your Home
1985	Electromagnets
1412	The Flow of Electricity
794	How To Produce Electric Current With Magnets
1976	Learning About Electrical Current
145	Magnetic, Electric and Gravitational Fields
1657	Magnets
860	Magnets and Their Uses
142	Simple Demonstrations With Static Electricity

Filmstrips

6480	Electric Magnets	
6482	Electricity	
7467-7473	Electricity	
	7472	Buliding An Electric Generator
	7470	Electricity and Heat
	7471	Electricity and Magnetism
	7468	Electricity by Chemical Reaction
	7469	Electricity in Circuits
	7467	Experimenting With Static Electricity
6390	Frictional Electricity	
7752	An Introduction to Electricity	
5998	Magnetic Fields	
6481	Permanent Magnets	
7759-7762	Understanding Electricity	
	7762	Electric Circuits and How They Work
	7760	How Electricity is Produced
	7761	Producing Static Electricity
5997	What is Magnetism?	

Filmstrips (Continued)

6174	What is Magnetism?
6202	Wonder of Electricity
6203	Wonders of Electric Light
6206	Wonder of the Telegraph
6204	Wonder of the Telephone

A-V Media Approved for Purchase

Filmstrips

Jam Handy

- What Is Magnetism
- Magnetic Fields

Understanding Electricity

- What Is Current Electricity
- Using Electricity Safely

True Book Physical Science

- Finding Out About Electricity

Tapes

Imperial Productions

- Let's Find Out About Electricity

Transparencies

Milliken

- Electricity

EARTH SCIENCE

EARTH SCIENCE

This section, Earth Science, emphasizes understandings about the planet Earth and the universe. It consists of nine units: two in the area of Geology, three in Meteorology, and four in Astronomy.

The concepts in Earth Science are taken from Life and Physical Science. Earth Science is the study of matter, energy, and organisms as they relate to the earth and to other objects in the universe.

The earth is a continuum of matter from its center through the atmosphere. The matter of the earth is composed of three parts: the lithosphere, the hydrosphere, and the atmosphere. These parts are not always physically separated, but intermingle on and near the earth's surface.

The Lithosphere. Lithosphere means rock sphere. The lithosphere is the solid part of the earth. It consists of four layers. From the earth's surface to its center these are: the crust, the mantle, the outer core, and the inner core.

The crust is a layer of rock covered with soil. It varies in thickness from three miles under oceans to as much as forty miles under land areas. In comparison to the size of the earth, the crust is like a thin outer skin.

The mantle is a layer of solid rock about 1800 miles thick. It consists of silicon, oxygen, iron, aluminum, and magnesium. It responds to the earth's forces by flowing like a plastic material under pressure. The upper part has a temperature of about 870 degrees C (1600 degrees F). The temperature increases through the mantle to about 2200 degrees C (4000 degrees F) where the mantle meets the outer core.

The outer core is about 1,400 miles thick. Scientists believe it is made of molten iron and nickel. Its temperature ranges from 2,200 degrees C (4000 degrees F) to perhaps 5000 degrees C (9000 degrees F).

The inner core is the center of the earth. Scientists believe that it is composed of solid iron and nickel with temperatures going perhaps above 5000 degrees C (9000 degrees F).

The Hydrosphere. The hydrosphere is the liquid part of the earth, the liquid being, of course, water. Water is found in lakes, streams, oceans, and underground. Water covers approximately seventy percent of the earth's surface. The oceans provide people with water, food, and mineral products. Water wears down land and distributes it to other parts of the earth.

There are no units dealing with the hydrosphere alone. However, the three meteorology units are related to both the hydrosphere and the atmosphere. These are: Air and Water, Observing the Weather, and Forecasting the Weather.

The Atmosphere. The atmosphere is the "ocean" of air that completely surrounds the liquid and solid parts of the earth. It is the gaseous part of the earth. Air, along with water, wears down, transports, and deposits sand and soil, changing the surface of the earth.

Living organisms are dependent upon air. Plants and animals on land use the materials in the air for respiration and food. Plants and animals that live in water use the air that is dissolved in the water.

The changing conditions in the atmosphere cause the phenomena we know as weather. These changes involve the interaction of air and water and a tremendous amount of energy from the sun, the earth's gravity, and the motions of the earth.

The Universe. The earth is one planet in the solar system. The solar system is one small part of the Milky Way Galaxy. There are an unknown number of galaxies. The universe is endless and beyond our comprehension.

Man has explored only a small part of the universe. The objects and forces in the universe, although not completely unlike those on the earth, are of such great magnitude and separated by such great expanses of space, that they demand our special attention. The concepts of interaction, system, frame of reference, relative size, relative motion, and gravitation are especially useful in studying the objects in the universe.

The units dealing with the universe make up the Astronomy part of this section. They are: The Sun, Moon, and Earth System, The Solar System, The Universe, and Space Travel.

ROCKS AND MINERALS

Background

Rocks are composed of minerals. Minerals are substances; that is, they have definite compositions. The elements combine in many ways to form the approximately 2,000 minerals that have been recognized. The most abundant elements: oxygen, silicon, aluminum, and iron, make up 90 percent of the earth's crust. Calcium, sodium, potassium, magnesium, titanium, hydogen, phosphorus, and carbon account for 8 percent.

About twenty minerals compose all the rocks. Feldspar is the most abundant mineral in the earth's crust, and quartz is the second most abundant mineral. Most rocks are composed of more than one mineral and almost all contain silica.

Properties. Rocks and minerals have distinct properties which make possible the identification of a particular specimen. Some properties, such as color, texture, and luster can be determined directly with the senses. Other properties, such as hardness and interaction with other substances, may be determined by testing.

Hardness. One property by which rocks and minerals are identified is hardness. Talc is so soft it can be ground between the fingers and is used as a face powder. Diamond is the hardest known natural substance. Hardness is measured on a ten-point scale with talc having a hardness of No. 1 and diamond, No. 10. This ten-point standard is known as Moh's scale of hardness.

Streak Color. The color of a rock when pulverized is often different from the color of the rock as it is found in nature. This color can be observed by the streak it makes on unglazed tile. The streak color is characteristic of the rock and can be used to help identify the specimen. Some rocks are soft enough to make a streak on paper (graphite, talc, gypsum).

Interaction. When rocks interact with water some of them change color, some dissolve, some flake off and begin to disintegrate and some absorb water. Some rocks have interesting interactions with acid. Rocks containing calcium carbonate (limestone and marble) will react with acid, releasing dioxide gas. Vinegar works well and is safe to use in the classroom. The evidence of the interaction will be the appearance of bubbles and the dissolving of part or all of the sample.

Density. The meaning of density may be difficult for children to understand. However, they can experience kinesthetically that some materials are heavy for their size and others are light. Rocks and minerals vary greatly in density ranging from pumice which is so light it floats in water to the very dense metallic ores. The density of a specific mineral may vary greatly from specimen to specimen. However, if other information is known, the density of a specimen can be a clue to its identity.

Cleavage and Fracture. The way a rock or mineral breaks can be a clue to its identity. Some crystals split readily into fragments having sharp, straight edges and smooth surfaces. This manner of splitting or breaking is called cleavage. Any other kind of break is a fracture.

Some rocks and minerals break more easily than others. The ability to hold together is called tenacity. Tenacity is not to be confused with hardness. Glass is harder than plastic, but glass will break more easily than plastic.

Formation of Rocks. Rocks are classified as igneous, sedimentary, or metamorphic, according to the ways they are formed.

Igneous. Igneous rocks form when molten rock cools. The faster a mineral cools, the smaller the crystal it forms. Intrusive rocks cool slowly beneath the earth's surface and have larger crystals than extrusive rocks which pour out onto the earth's surface and cool rapidly. Obsidian cools so rapidly that crystals cannot form. This accounts for its glassy appearance.

Sedimentary. Mud, sand, shells, bones, and rock fragments accumulate on land or in water. These sediments are deposited in layers. Pressure from the sediments and water compact these. Water may precipitate a cementing agent such as iron oxide, calcium carbonate, or silica which fills the space between sediment particles and hardens the sediments, forming rock.

Sandstone is cemented sand grains. Conglomerate is cemented rock fragments. Limestone is composed of rock, bone, and shell fragments cemented together.

Metamorphic. Igneous and sedimentary rocks may change their crystalline structure under extreme pressure and heat and become metamorphosed. Metamorphic rocks may be changed further into other metamorphic forms.

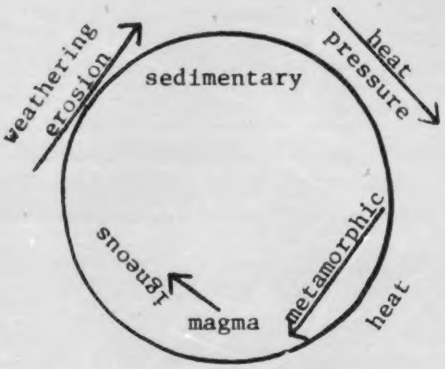
The Rock Cycle. In the region where the mantle meets the crust, pressures become so great that the resulting heat melts rock, forming igneous rock. This total process is cyclic in nature. However, most rocks do not go through the entire cycle. There are subcycles also. Sedimentary rocks will weather. The resulting material will erode, be redeposited, compacted, and, perhaps, cemented to form new sedimentary rock.

Rocks are changed from one kind to another as environmental conditions change. The cycle of rock change and reformation is never ending. Nothing is lost, but everything undergoes change. Each kind of rock remains for a time, is subjected to a different set of environmental conditions, begins to change, and eventually becomes a different kind of rock.

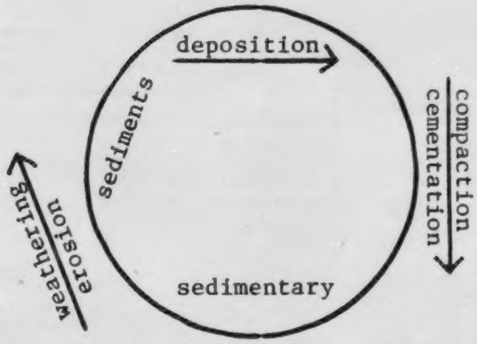
ROCK FORMATION CHART

Rock Type	How Formed	Properties	Rocks
Igneous	Cooled from molten rock (magma)		
	Extrusive	glassy, no crystals	obsidian, pumice
		fine crystals (need magnification to see)	
		dark	basalt
		light	felsite
		large and small crystals	porphyry
	Intrusive	visible crystals	granite, syemite, gabbro, diorite, diabase
		very large crystals	pegmatite
Sedimentary	Deposited by wind, water, or glaciers, compacted by own weight and/or by water	coarse grained mixture of sand and gravel	conglomerate
		small grained	sandstone
		fine grained, smooth	shale
	Deposited chemically or formed from shells	smooth, no grains	limestone
Metamorphic	Changed in form from sedimentary, igneous or metamorphic rock	coarsely banded, from granite	gneiss
		thin layers, from shale	slate
		hard, fused crystals, from sandstone	quartzite
		crystalline, from limestone	marble
		black, shiny, from bituminous coal	anthracite coal

Rock Cycles


weathering
erosion
sedimentary
heat
pressure
metamorphic
heat
igneous
magma

Rock Cycle


deposition
sediments
compaction
cementation
weathering
erosion
sedimentary

Sedimentary Cycle

Crystals. Minerals often form in geometric shapes called crystals. Complete crystals are rare and are formed only under the most favorable conditions. Partial crystals are common and usually provide sufficient evidence for identification. Crystals may form when liquids cool to form solids. Crystals may also form from solutions either by precipitation or by evaporation.

Rationale

The unit, Rocks and Minerals, is designed to help students; (1) observe and describe the properties of rocks and minerals, (2) identify rocks and minerals by their properties, (3) classify rocks by the ways they were formed, and (4) investigate the properties and formation of crystals.

The materials found in the earth's crust are important to man because many of them are necessary to sustain life. The experiences suggested in this unit help familiarize students with these materials. Children who have an understanding of the mineral resources of the earth are more likely to develop the desire to conserve them and to use them wisely.

Glossary of Concepts

Rock	Solid material made of minerals.
Mineral	A natural substance (element or compound) found in the earth, having a specific chemical composition.
Property	The characteristic or attribute of an object.
Texture	Relative roughness or smoothness. The texture of a rock depends upon the size of its grains.

Luster	The way a rock reflects light. Rocks may be dull, glassy, greasy, or metallic in luster.
Color	Rocks have distinct colors depending upon their mineral content.
Density	The weight per unit of volume; how tightly material is packed together.
Cleavage	The splitting of a rock or mineral into fragments having sharp, straight edges and smooth, flat surfaces.
Fracture	The breaking of a rock or mineral that results in a rough or irregular pattern.
Hardness	Relative resistance to scratching.
Interaction	Objects interact when they do something to each other.
Igneous	Rocks that are formed by materials that were molten and then cooled.
Sedimentary	Rocks that are formed by materials (sediments) deposited in water.
Metamorphic	Sedimentary and igneous rocks that have been changed by heat and pressure.
Deposition	The laying down of sediments.
Compaction	The packing together of sediment particles.
Cementation	The binding together of particles by the filling of spaces between them. Cementation consolidates the sediment into rock.
Rock Cycle	The changing of rock forms from one to another and back to the original form.
Crystal	A solid substance having flat surfaces, sharp edges, and definite angles between surfaces.
Crystallization	The building of a crystal by cooling of liquid materials or precipitating or evaporating from solution.
Solution	A uniform mixture of two or more substances. The particles are evenly distributed, and the mixture has the appearance of one substance.

Saturated Solution	A solution at maximum concentration. A saturated solution is clear but can contain undissolved materials.
Supersaturated Solution	A solution that contains more solute than it would if undissolved solute were present.

Investigations

Instructional Objective

Given rock samples, compare them with the minerals of which they are composed.

Concepts

Rock
Mineral

Materials needed:

- granite samples (gray, red)
- quartz (preferably milky quartz)
- feldspar
- mica, biotite, and muscovite
- hornblende
- crushed marble
- crushed granite
- hand lens
- paper trays
- nails

Learning activity:

This activity illustrates the composition of granite and helps students distinguish the difference between a rock and a mineral. Granite is a rock composed of two or more of the following minerals: quartz, feldspar, mica, and hornblende. Marble is a rock composed of one mineral, calcium carbonate. After students have completed this activity, discuss the meanings of "rock" and "mineral."

Set up a learning station. Students may work individually or in small groups. Place trays of granite samples and other rock samples on a small table or a desk. Provide each student with a nail and hand lens on a paper tray. Give each student a set of directions and a data sheet. Prepare some crushed granite of each type and some crushed marble by striking a small sample with a hammer. Label all samples used in this activity.

Directions

1. Observe each sample of granite carefully. Use the hand lens.
2. Try to separate grains with the nail. Observe these with the hand lens. (If this does not work well, provide samples of crushed granite.)
3. Compare the grains with the samples of quartz, feldspar, mica, and hornblende. See if you can identify pieces of quartz, feldspar, mica, or hornblende in the granite samples.
4. Examine crushed marble with a hand lens or bioscope. Compare the grains with one another. Record information on the sheet.

DATA SHEET

		Mineral Grains		
Sample	Colors	Size	Color	Shape
Red granite				
Gray granite				
Marble				

How many kinds of grains did you find in the sample of gray granite? ________________________________

The red granite? ________________________________

The marble? ________________________________

Each type of grain is a separate mineral.

How many minerals does gray granite contain? ________________

Red granite? ________________________________

Marble? ________________________________

What do you think would be a good definition of a rock? ______

____

____

What do you think would be a good definition of a mineral? ___

____

____

Instructional Objective

Given a set of rocks, describe each rock by its properties.

Concepts

Rock
Property
Texture
Luster
Color

Materials needed:

Rock and mineral samples:
- limestone
- sandstone
- shale
- granite
- gypsum
- quartz
- halite (rock salt)

For each student:
- hand lens

Learning activities:

1. Distribute a piece of limestone, sandstone, or some other common rock to each child. Ask the students to tell anything they can about the rock. If they know the word "property," ask them to name all the properties of the rock. List these on the chalk board for future use.

2. Distribute other rock specimens, such as granite, shale, halite, quartz, and gypsum. List the properties of one specimen at a time. Ask the students to compare the properties of two or more rocks. Use a hand lens to examine rocks more closely.

3. Ask the students to describe how each specimen feels. Make a list of the words they suggest. Introduce the word "texture" and define it. Texture words may include rough, smooth, grainy, crystals, slick, or sharp. Distribute hand lenses so students can observe the grains or crystals of a specimen.

4. Ask the students to describe how each specimen reflects light. Introduce the word "luster." Make a list of words that describe luster, such as shiny, dull, glassy, greasy.

5. Instruct students to separate rocks by color. Write the various colors on the chalk board or have the students list them on paper. Place rocks of similar color in order of intensity, shade, or tint. Example: pink, dark red, maroon.

6. Record the properties of the rocks on one of the charts shown below. Make a class chart to illustrate how to record observations. The teacher may prefer that the class develop its own chart.

Example 1:

Color	Texture	Luster	Other Properties	Name
gray	rough	dull		limestone

Example 2:

Name of rock ______________________________
What color is it? ______________________________
Is it dull or shiny? ______________________________
Is it rough or smooth? ______________________________
Does it have grains? ______________________________
Are all grains the same size? ______________________________
Are all grains the same color? ______________________________
What else can you say about this rock? ______________________________

Instructional Objective	Concept
Given rock or mineral specimens, classify them by their densities.	Density

Materials needed:

rock samples
paper trays
rulers
balance
graduated cylinder

Learning activities:

1. Distribute eight to ten rock samples to groups of four students each. Instruct each student to pick up two rocks and decide which is heavier. Let them simply weigh the rocks in their hands. Use a simple balance to determine which of two rocks is heavier. A ruler balanced on a pen or pencil might suffice. You may wish to let students take turns on the class balance.

   Instruct each group to line up their rocks in order of their weight. Then ask them if the rocks are also lined up by size. Find examples of small rocks being heavier than large ones. Find examples of rocks of near equal volume that have very different weights. Pupils may wish to classify rocks as being light or heavy.

2. Develop the concept of "density." Compare the weight of a piece of pumice to that of a piece of smaller, heavier rock. Define density as how tightly the material is packed together. Illustrate by comparing the densities of other materials such as feathers and clay, aluminum and iron, and a dry and a wet sponge.

3. Optional Activity. Demonstrate the calculation of the density of a rock or mineral specimen. Some pupils may be interested in calculating the density of some samples on their own.

   Weigh the sample on a balance and report its weight in grams. If that specimen is small enough, drop it into a graduated cylinder containing water and measure its displacement. If it is too large for the cylinder, fill a large container with water, drop the rock in carefully, collect and measure the overflow.

Divide the number of grams by the number of milliliters and report the quotient in grams per milliliter.

Instructional Objective	Concepts
Given rock and mineral specimens, describe the way they break, identify those that have cleavage, and describe their pattern of cleavage and/or fracture.	Cleavage Fracture

Materials needed:

samples of halite, mica, slate, shale, sandstone, limestone, granite
hammer
cloth
hand lens
pieces of plastic, rubber, and copper

Learning activities:

1. Split samples of shale by striking them, prying with a flat blade or pulling with your fingers. Break pieces of shale with your hands. Let the students explore different ways to break samples, such as dropping, rubbing, and striking with a hammer. Demonstrate cleavage by splitting other rocks. Do this sparingly unless the particular samples are in great abundance. Introduce the word "cleavage." Let the students try to define it. Look at other rocks and mineral specimens for evidence of cleavage. Viewing with a hand lens often reveals flat surfaces and lines at the edges of cleavage planes. Describe and compare cleavages in various specimens.

2. Wrap one sample of granite or marble in a cloth and strike with a hammer. Describe the freshly broken surfaces and compare them to the worn surfaces. Compare these surfaces with the slate or shale. WARNING: Place rocks on a hard surface when breaking them to prevent damage to floors and table tops. Make inferences about how the original rock had been made smooth. Introduce the word "fracture." Let the students try to define it.

3. Classify the samples in this activity by cleavage and fracture. Rocks that have good cleavage in one or two planes may also fracture (shale, slate, and mica).

   Have students place the same samples in order of their hardness. Add some plastic, rubber, and copper to the collection. Ask the children if soft materials are easier to break than hard materials.

Instructional Objective	Concept
Given a set of rocks, determine the comparative hardness of each on a ten-point scale.	Hardness

Materials needed:

- gypsum
- quartz
- limestone
- sandstone
- feldspar
- marble
- nails
- pennies
- files
- glass

Learning activity:

Distribute rocks and minerals of varying hardness to groups of three or four children. Instruct them to try to scratch the rocks with a nail. Put those that can be scratched with the nail in one group and those that cannot be scratched in another.

Instruct the students to try to scratch one rock with another. Place the rocks in order according to their hardness. Rock A is harder than rock B if rock A scratches rock B. If the sets of rocks are different for each group of students, let them exchange sets and compare hardnesses.

Use fingernails, pennies, nails, glass, files, and available hardness minerals to determine the hardness of a rock according to Moh's Scale of Hardness. If necessary, demonstrate how this is done before letting students try it on their own.

Moh's Scale of Hardness

Moh's Number	Comparison Mineral	Field Scale
1	Talc	Pieces flake off with fingernail
2	Gypsum	Can be scratched with fingernail
3	Calcite	Cannot be scratched by fingernail Will not scratch a penny
4	Fluorite	Will scratch a penny
5	Apatite	Will scratch a penny Can be scratched by an iron nail
6	Feldspar	Will scratch glass Can be scratched by an iron file
7	Quartz	As hard as a file
8	Topaz	Will scratch a file; will scratch Quartz
9	Corrundum	Will scratch a file
10	Diamond	Hardest known substance

Instructional Objective	Concept
Given a rock or mineral sample, describe its interaction with water and vinegar. Make inferences concerning its chemical content.	Interaction

Materials needed:

limestone
sandstone
granite
quartz
marble
chalk
feldspar
halite (rock salt)
gypsum
pumice
shells
vinegar
plastic tumblers

Learning activities:

1. Place each of the rock specimens in a separate tumbler and cover with water. Label each container with the name of the rock and record observations:

Rock	Observations
Halite	
Gypsum	
Sandstone	
Granite	
Quartz	
Pumice	

Keep the materials in the tumblers overnight and record further changes.

Place several drops of water from each tumbler on a microscope slide or perhaps on the underside of an inverted tumbler and allow to dry. As a control, place several drops of tap water on a slide and compare this to the others. Ask pupils to tell why this is done.

Introduce and define "interaction." Ask what conclusions can be drawn from the interaction of the rocks with water. Possible evidences of interaction are: the rock changed color; the material dissolved; the material fell apart but did not dissolve; some grains appeared in the bottom of the tumbler.

2. Place a sample of each rock into a tumbler and add vinegar. Record the observations on a chart. Two techniques may be used. Drops of vinegar may be placed on the sample, or the sample may be immersed in vinegar. Try the same procedure using fragments of shells. Infer whether the sample contains calcium carbonate.

Instructional Objective	Concept
Given a specific rock, record its properties.	Properties

Materials needed:

one rock specimen	streak plates
chart for student records	water
rock and mineral charts	vinegar
set of hardness minerals	hand lenses
pennies, nails, glass, files	

Learning activity:

Assign a rock specimen to each student. Instruct the students to observe their specimens carefully and record the observable properties first (color, texture, luster, and grains or crystals).

Testing for hardness, streak, and interaction with water and vinegar may be done as a whole class activity, but preferably each child will have access to the materials and will test and record this data independently.

Instruct the students to rub a specimen across a porcelain streak plate. Describe and record the color of the streak. Do not touch crystal points if you wish to avoid damaging the specimen. The streak plate may be wiped clean and reused.

The determination of density may be done by simply weighing the sample in the hand. The more advanced student may wish to measure and weigh his specimen and calculate its density. This is significant for only certain minerals.

The students may use rock and mineral charts to identify their specimens. They should compare the properties listed on the chart to their data, and record the name of the rock that most closely matches this data.

Color	Texture Luster	Cleavage Fracture	Hardness	Streak Color	Interaction Water/Vinegar	Density	Other Properties	Name

Instructional Objective

Given reference materials and local resources (1) identify and explore uses of rocks and minerals in the home and community and (2) identify occupations related to rocks and minerals.

Concepts

Utilization of rocks and minerals
Occupations

Materials needed:

reference materials
community resources--businesses and people

Learning activities:

1. Take students on a walk through their community and let them identify uses of rocks and minerals that they observe. Ask, "How have people changed materials they have taken from the earth to make them useful? What skills are needed to work with these materials? What occupations use rocks and minerals?"

Some examples of the uses of rocks and minerals are walls and fences, buildings, dams, monuments, rock gardens, jewelry, and art and craft materials.

Some less obvious uses are minerals in food; metals extracted from ores; glass, plaster, and cement; and cosmetics.

2. Make displays of objects or pictures of objects that have come from the earth. Make flow charts to show how materials were modified to produce objects useful to man. Indicate the people and occupations involved in their production.

3. Invite a resource person to tell how his job is related to rocks and minerals.

Instructional Objective

Given a collection of rocks composed of sedimentary, igneous, and metamorphic samples, describe the properties of each.

Concepts

Igneous
Sedimentary
Metamorphic

Materials needed:

basalt
obsidian
pumice
granite
sandstone
shale
limestone
conglomerate
quartzite
gneiss
marble
slate

Learning activities:

The following procedures should be carried out individually or in small groups.

1. Have students examine the rock samples listed above and describe the properties of each. Note similarities and differences of each sample. List the properties on a chart like the one below.

Rock	Texture	Color	Hardness	Other Properties

2. Use data previously collected and compare the properties of igneous rocks with the properties of sedimentary and metamorphic rocks. Are there any patterns of properties? How do the three types of rocks compare in hardness, texture, luster, and tenacity?

3. Some students may wish to make an individual display of one sedimentary, one igneous, and one metamorphic rock. They may wish to bring in samples and make trades to complete their displays.

Instructional Objective

Given appropriate materials, demonstrate sedimentation.

Concepts

Deposition
Compaction
Cementation

Materials needed:

- large jars
- test tubes
- 20 cm conduit pipe
- soil samples
- rubber or plastic tube
- syringe
- hand lenses
- wax paper
- sand
- gravel
- plaster of paris
- paper cup
- graduated cylinder

Learning activities:

1. Have groups of students mix one part soil with two parts of water in a jar. Stir and let settle for an hour or two. Observe with a hand lens. Siphon the water or draw it off with a syringe.

   Let the jars of sediment dry over a period and observe.

2. Develop the concepts "deposition" and "compaction." Some other words that need to be emphasized are soil, silt, gravel, sediment, and layers.

3. Pour 40 ml of dry sand into a graduated cylinder. Add plaster of paris to sand and shake until the plaster of paris begins to pile up on top of the sand. Measure the amount of plaster of paris used. (It may be poured from another graduated cylinder.) Pour the mixture into a paper cup. Add water and stir until the whole mixture is wet.

   Repeat the activity using gravel in place of sand. Try mixtures of sand and gravel.

   Introduce the word "cementation" and discuss its meaning. Have students make inferences from these experiences about the kinds of rock that might have been formed by cementation. Examine samples of sandstone for evidence of cementation.

Instructional Objective	Concept
Given pairs of related rocks, describe the processes by which they have evolved.	Rock cycle

Materials needed:

- shale
- limestone
- sandstone
- granite
- bituminous coal
- slate
- marble
- quartzite
- gneiss
- anthracite
- paper trays
- hand lenses
- sea shells
- vinegar
- reference materials

Learning activities:

1. Provide each student with a paper tray and a hand lens. Make available the rocks listed above. Let students work individually or in small groups. Instruct them to examine the specimens carefully and do the following:

   a. Compare a specimen of slate with a specimen of shale. Which is harder? Which splits more easily?

   b. Compare a sample of sandstone and quartzite. Which is harder? Which flakes off more easily?

   c. Compare a specimen of granite with a sample of gneiss. What differences do you see? What similarities?

   d. Compare a specimen of limestone with a specimen of marble. What differences and similarities do you see? Test both with vinegar. What inference might you make about the results? Test a fragment of a seashell with vinegar. How do you think limestone was formed?

   e. Compare bituminous coal with anthracite coal. What similarities do you see? What differences? Which do you think was formed first? Ask the students to try to infer which of these specimens might have been formed under water. Is there evidence of layering? Are there any imprints or molds of living organisms?

2. Have the students find a rock that has holes in it and make inferences about how the holes were produced. Ask them if they can use this clue to infer how the rock was formed.

3. Introduce the term "rock cycle" and discuss its meaning in terms of the changes in rocks.

4. Ask, "In general, what ways have rocks changed? What forces do you think caused them to change?"

Instructional Objective	Concept
Given reference materials, describe the processes by which igneous and metamorphic rocks are formed.	Rock cycle

Materials needed:

reference books and other media

Learning activities:

1. Have students use references to find information about the formation of igneous and metamorphic rocks. Ask them to describe the formation of several igneous and metamorphic rocks. Have them identify the variables that affect the appearance of various metamorphic rocks.

2. Ask the students to make hypotheses concerning the effect of heat and pressure on rocks. Some possible hypotheses are:

   Heat and pressure make rocks harder, more compact, and may melt the rock and change the crystals.

   Discuss the words metamorphic and metamorphism in terms of the changes in the rocks the students have explored.

Instructional Objective:	Concept
Given rock and mineral specimens, recognize examples of crystals.	Crystal

Materials needed:

Quartz crystals of various sizes
pencil and paper
rock salt
styrofoam cup
snow
hand lens
black paper

Learning activities:

1. Use two or three large crystals of quartz. Count the sides of the crystals. Trace the outline of a crystal on a sheet of paper and measure the angles bounded by the crystal faces. Compare the results of several students. Note the measurement range. Find the average of the measurement determined by six students.

2. Place three or four teaspoons of rock salt in a styrofoam cup and allow it to stand for a period of days. Observe the change that occurs. If no change occurs after a week, add a teaspoon of water. Is there any evidence of interaction? What materials interacted with the salt?

3. Snowflakes are interesting to observe. Take the children outdoors when it is snowing. Let them observe snowflakes on their clothing or on sheets of black paper. Ask, "How can you tell that snowflakes are crystals? How are they like one another? How are they different from one another?"

Instructional Objective	Concept
Given crystals and crystal models, match crystals with corresponding crystal models.	Crystal

Materials needed:

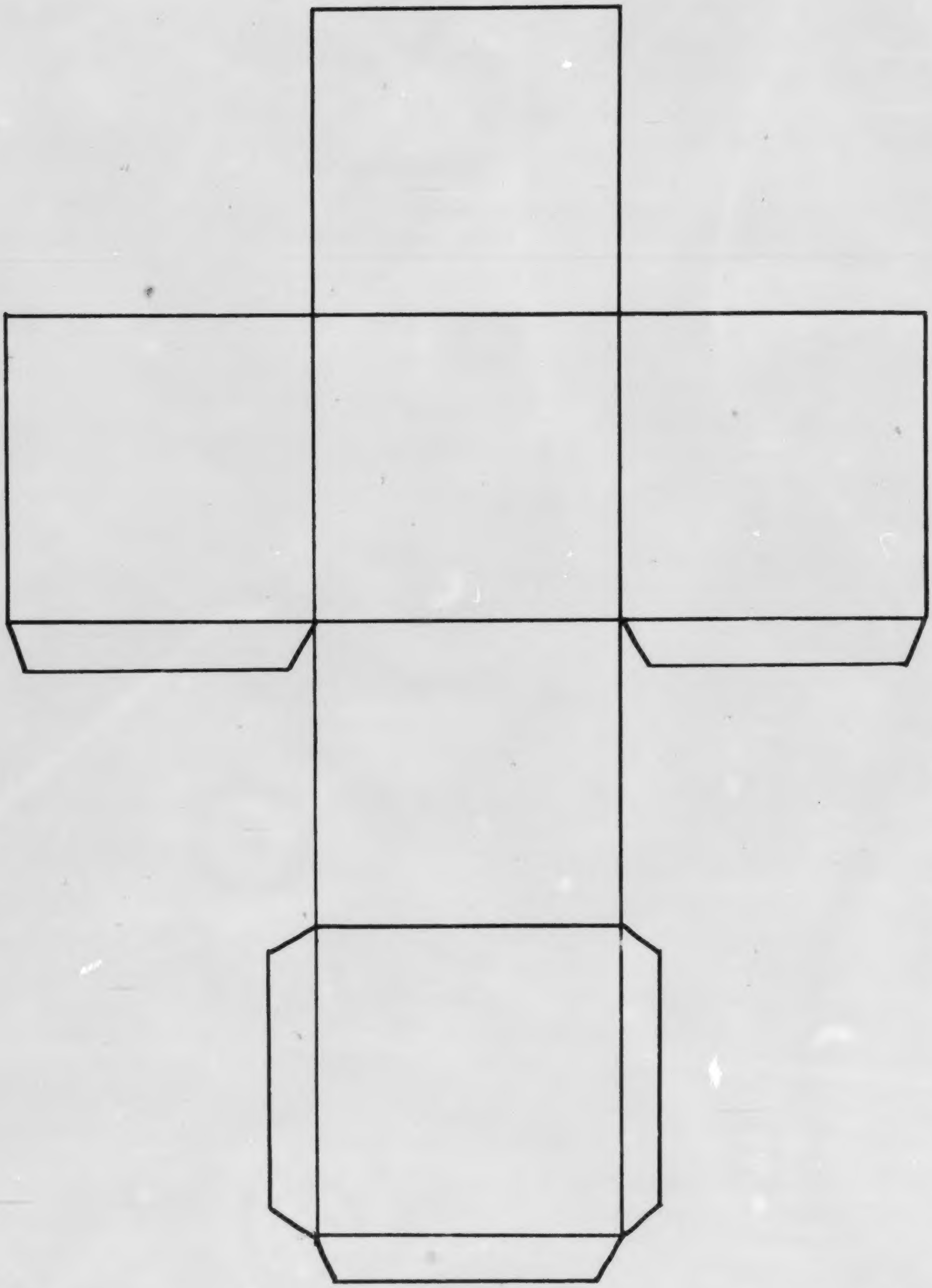
crystal model patterns
glue or paste
scissors
hand lenses

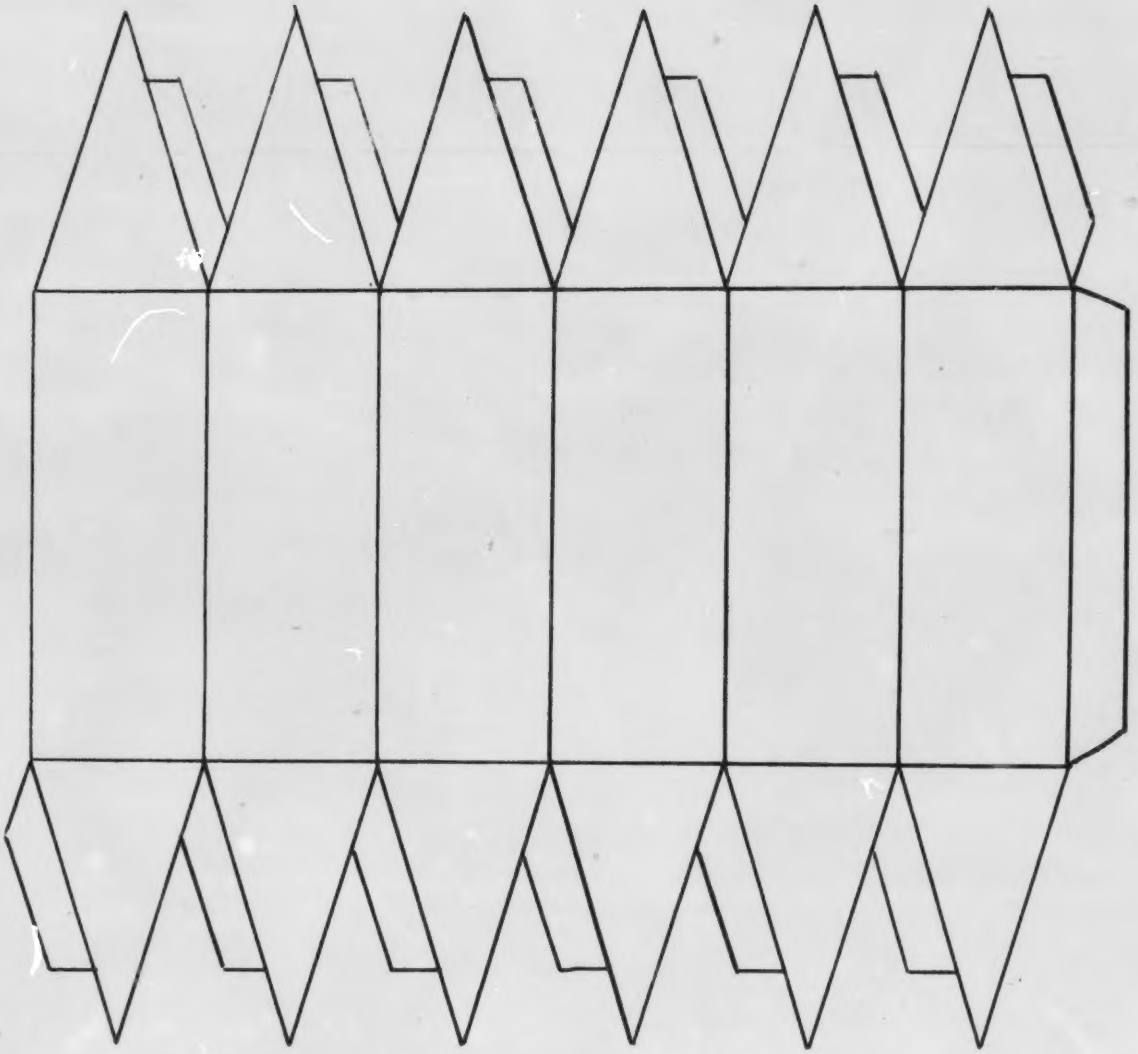
Learning activity:

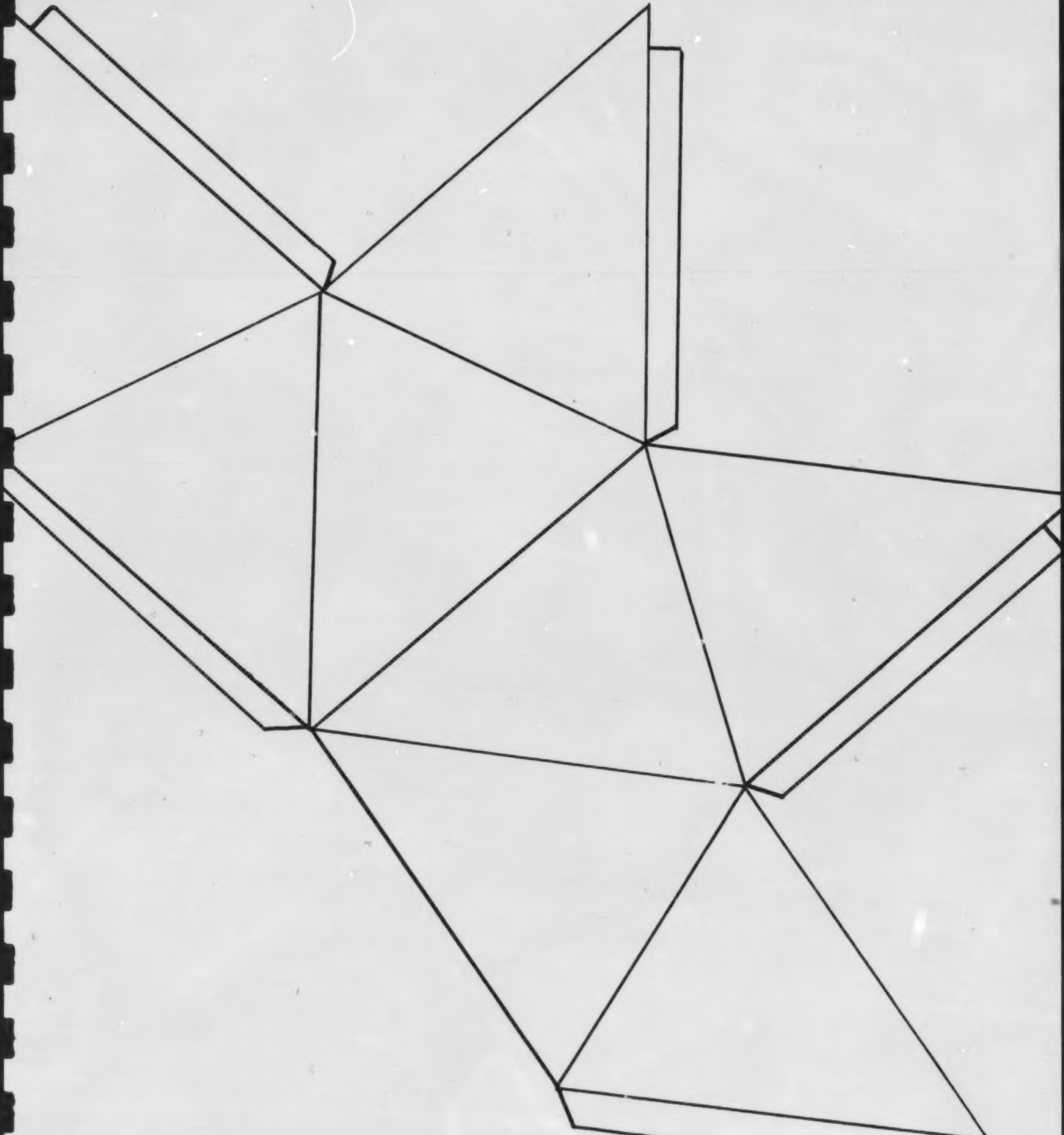
Make ditto masters from the crystal model patterns and duplicate copies for students. Have students cut out the patterns and assemble the crystal models by pasting the flaps inside the next section of the model. Have them describe the shape of the models. Let them search through the class rock and mineral collection to find samples similar in shape to the models.

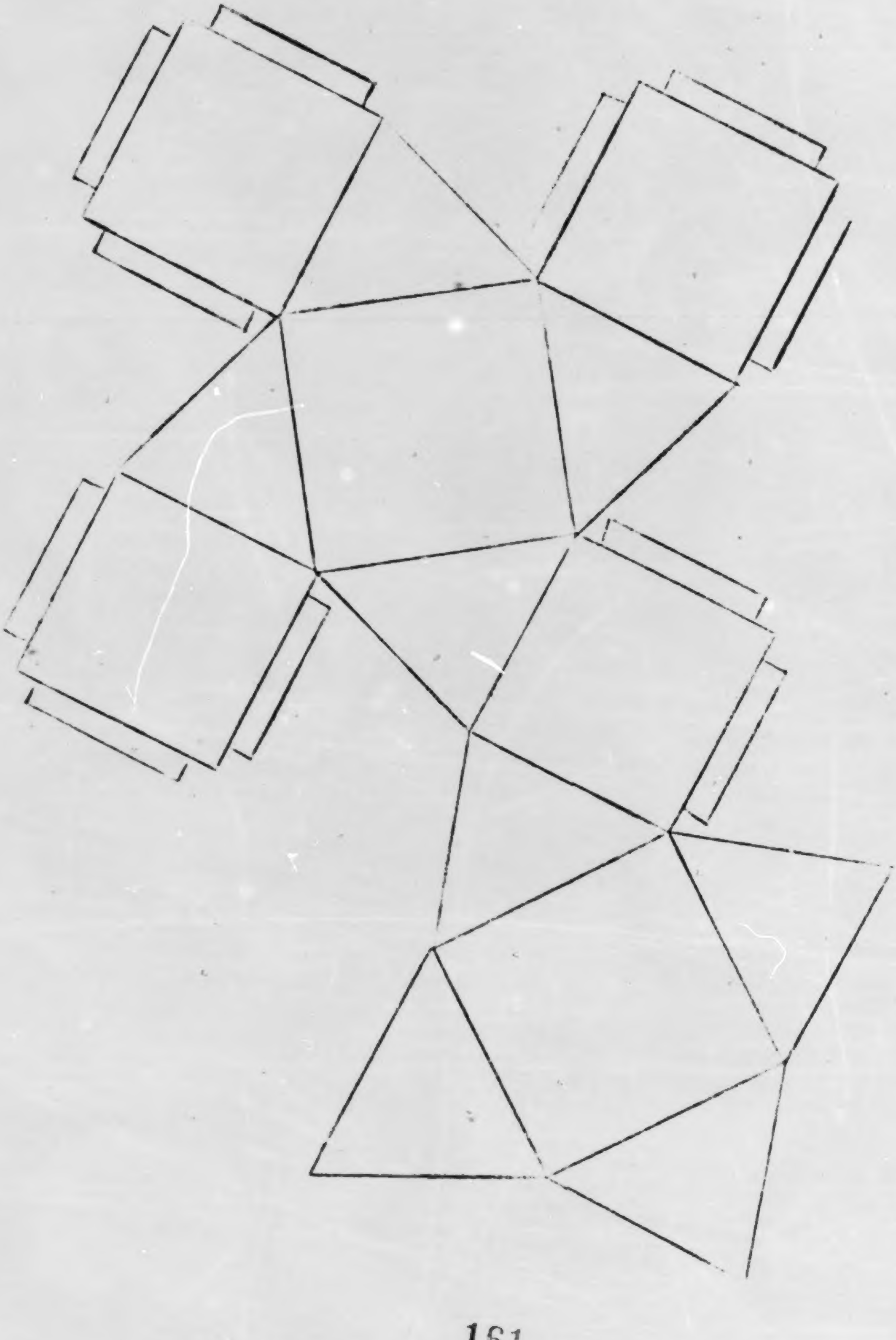
Crystal shapes are very interesting but are too complex for most intermediate grade students to classify. However, if some students are interested, information is available in reference books.

Instructional Objective	Concept
Given rock and mineral specimens containing crystals, infer the conditions under which they were formed.	Crystallization









Materials needed:

- rock collection
- hand lens
- microscope slide
- salt solution
- bioscope

Learning activities:

1. Use the rock collection for a crystal hunt. Let each child have a hand lens to observe rocks and look for crystals. Classify the rocks into those that have visible crystals and those that do not. Look for samples having crystals of more than one size. Such a rock is classified as a porphyry. Have the children infer how the crystals were formed.

2. This activity may be done as a demonstration or as an individual or small group activity.

   Spread two or three drops of salt solution on a microscope slide. Place the single slide on the bioscope and observe. The heat from the bulb will evaporate the water quickly, and crystals will be formed. When the liquid dries, move the slide and observe crystals at different locations on the slide. Are all the crystals the same size? Where were the larger ones found? Where were the smaller ones found?

   Pupils may wish to experiment by placing more of the solution on the slide and observe the buildup of crystals.

   Try other materials, such as sugar, sodium thiosulfate, copper sulfate, and epsom salts.

   Introduce the word "crystallization." Discuss the formation of crystals by evaporation.

Instructional Objective

Given a number of examples of crystal formation, identify the variables that determine the size of crystals

Concepts

Crystallization
Variables

Materials needed:

- 2 cups of sugar
- 3/4 cup of milk
- 2 squares of chocolate
- 2 tablespoons of light corn syrup
- 2 tablespoons of butter
- hot plate
- candy thermometer
- saucepan
- bowl
- 2 small cake pans

Learning activity:

Caution: This experiment will not work with packaged fudge.

Cook 2 cups of sugar, 2 squares of chocolate, 3/4 cup of milk, and 2 tablespoons of light corn syrup slowly until the chocolate melts, stirring gently. Boil without stirring to 112° C. (234° F.) or until the mixture forms a soft ball when dropped into cold water. Remove the mixture from the heat, add 2 tablespoons of butter, and let stand until cool. Pour half the mixture into a pan and let stand. Pour the other half into a bowl and beat until thick. Place this half of the fudge in the refrigerator until it hardens. Compare the texture of the two batches of fudge. Note which one has larger grains. Decide which one is like an intrusive igneous rock and which one is similar to an extrusive igneous rock.

Discuss the variables that affect the size of crystals. How do the rate of cooling, the rate of evaporation, and stirring affect the size of crystals?

Instructional Objective

Given a saturated or supersaturated solution, recrystallize the solute from the solution.

Concepts

Saturated
Supersatured

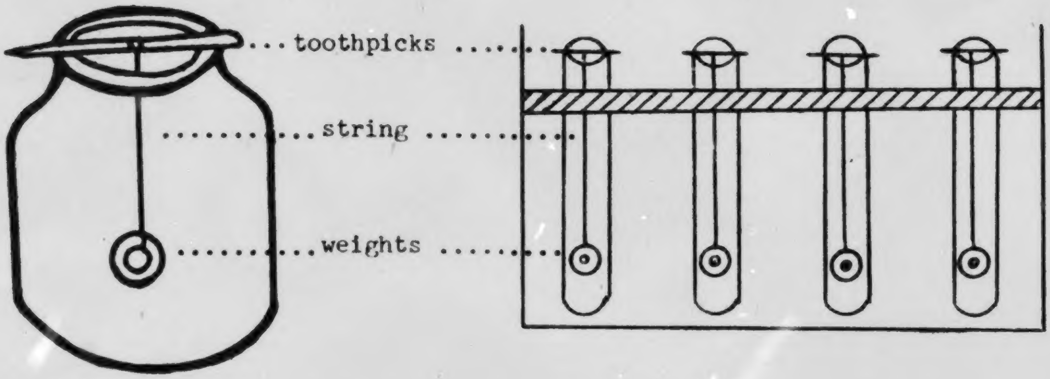
Materials needed:

salt
sugar
pyrex beaker or cooking pan
glass jars or test tubes
water
twine
metal washers (for weights)
hand lenses
toothpicks
hot plate
shallow dish
alum
sodium thiosulfate
epsom salts

Learning activities:

1. Have small groups or individual students prepare saturated sugar solutions using two parts of sugar to one part of boiling water. Pour the solutions into jars or test tubes. Suspend a weighted piece of twine into the solution. Place the solutions in various parts of the room and allow them to stand undisturbed for several days or longer. Observe and describe what occurs.

2. Prepare solutions of other substances such as alum, sodium thiosulfate, and epsom salts. Try to crystallize them on twine as described in the preceding activity.



Instructional Objective

Given reference materials report on commercial uses of crystals.

Concept

Utilization of Crystals

Materials needed:

reference materials

Learning activity:

# Have students use reference materials to find out ways crystals are produced and used commercially. Let them draw pictures to illustrate each example. Some examples are: synthetic diamonds, diamond saws and drills, electronics, jewelry, phonograph needles, cooking, optics, transistors, and solar electric cells.

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Materials listed in A-V Media Handbook - 1972

Sound Films

275	Rocks that Form on the Earth's Surface
276	Rocks that Originate Underground
1917	Rocks and Minerals
2301	Treasures of the Earth

Filmstrips

5947	Rocks and Minerals
6389	Desert Rocks and Minerals

Mounted Pictures

10242	Common Rocks and Rock-Forming Minerals

Materials Approved for Purchase - 1975

Filmstrips

Society for Visual Education

True Book Physical Science (6 Filmstrips)

Rocks and Minerals

Sound Filmstrips

Eye Gate House

Earth Science (10 Filmstrips/5 Cassettes)

Rocks and Minerals, Part 1
Rocks and Minerals, Part 2

Imperial Learning Corporation

A World of Change (6 Filmstrips/6 Cassettes)

The Rockmakers
The Influence of Heat
Hidden in the Rocks

Transparencies

Hubbard Scientific

Geology

8535	The Rock Cycle

Milliken Publishing Company

Rocks and Minerals (12 Transparencies/4 Masters)

Study Prints

Society for Visual Education, Inc.

SP 113	Important Minerals
SP 114	Common Rocks and Rock Forming Minerals

Instructional Supplements

Set 7	Igneous and Metamorphic Rocks
Set 11	Sedimentary Rocks
Set 13	Minerals

GEOLOGIC PROCESSES

Background

Changes in the earth's surface are the result of several geologic processes that are going on continually. These processes are of two types: those that produce differences in elevation and those that tend to level the earth's surface and make it more uniform. The first type includes diastrophism, volcanism, and sedimentation. The second type includes weathering and erosion.

Geologic processes have produced topographical features, formed the soil, and recorded the earth's history in rock strata.

Diastrophism. Diastrophism includes all the ways rocks are broken, folded or moved. Permanent deformations of the earth's crust result from the constant shifts in the underlying mantle. Movements in the mantle may be vertical or horizontal and produce uplifts and subsidence (lowering). When the crust is being raised in one place, it may well be lowered in another. Movements of the earth's crust produce folding and faulting. Sudden movements along faults produce earthquakes.

Scientists use several theories to account for movements of the earth's crust. Among these are the contraction theory, the expansion theory, the convection theory, and the continental drift (also called the plate tectonic theory). No single theory is completely satisfactory, nor are the theories mutually exclusive. The continental drift theory has received a great deal of attention recently.

Volcanism. A volcanic eruption begins with magma (hot fluid rock) deep within the earth. Liquid magma moves up through cracks and fissures. Some volcanoes erupt with great explosions and tremendous violence. Others, like Mauna Loa and Kilauea on the island of Hawaii, produce relatively quiet eruptions and lava flows.

Volcanoes may be active, dormant, or extinct. Active volcanoes are those that are erupting or have recently erupted. Dormant volcanoes are those that have not erupted but still show signs of activity. Volcanoes that are not expected to erupt again are called extinct. All three kinds are found in the Hawaiian Islands.

Volcanoes may produce cones, craters, and caldera. Cones are built up from lava, ash, and cinders. Craters are openings in the top of cones. A caldera is a large depressed basin formed when the top part of the cone is blown off or when the cone collapses and sinks.

Sedimentation. Through millions of years, the earth's surface has been slowly built up by deposits of sand, mud, silt, and organic materials. Wind, water, and glaciers have distributed these materials over the face of the earth. Layers of rock formed from these sediments may contain the fossils of organism which lived millions of years ago.

Weathering. Weathering refers to all the processes which contribute to the breaking down of rock in place. Weathering is of two types: mechanical weathering and chemical weathering. These often work together. Rock surfaces may be weakened by alternate heating and cooling and by the chemical action of tiny plants called lichens. Water seeps into the cracks, expands as it freezes, and splits the rocks. Seeds also fall into cracks in rocks and split them as the roots expand. Oxidation occurs as oxygen combines with minerals, such as iron, causing the parts of the rock to soften. Carbonic acid, formed by carbon dioxide dissolved in water, and humic acid, formed by decaying plants, can dissolve rocks such as limestone and marble. Caves are formed by the action of these acids on subterranean rock deposits.

Erosion. Erosion refers to the processes which break down rock and move the fragments to another place. It also includes the transporting of soil to another location. Water, ice, and wind are important agents of erosion.

Water erosion takes three forms--hydraulic action, solution, and abrasion. Hydraulic action is erosion by the force of moving water. Many minerals are dissolved by water. These may be carried great distances by streams and redeposited as the water evaporates or the acidity of the water is neutralized. In abrasion, water erodes by means of the particles it carries. Rocks are smoothed and rounded by abrasive action as they are tumbled by streams and waves.

Ice, in the form of glaciers, is a formidable earth mover. Three major types of glaciers are continental glaciers, valley glaciers, and ice caps. Glaciers have carved out many land forms, ground rock, deposited rock, sand, and soil, altered streams, and formed lakes when the ice melted.

Wind blows particles of sand and dust from one place to another. Wind blowing sand produces an abrasive force that undercuts cliffs and forms slender columns. Wind is the greatest cause of ocean waves which shape shorelines.

Topographical Features. Geologic forces form and change topographical features such as mountains, valleys, islands, caves, and coastlines. Mountains are formed by uplifts (folding and faulting), and volcanic action. Rivers and streams are formed by the erosion of water. Streams cut deep into the soil forming ravines and canyons. Subsequent erosion widens these into broad valleys. Islands are formed by uplifts and volcanic action. Coastlines are eroded by wave erosion and built up by sediments and volcanic action.

Soil. Soil is composed by tiny fragments of rock mixed with decaying plant and animal material called humus. Soil is formed by the weathering of rock and is distributed by forces of erosion. Partly, as a result of the inequalities in the erosion process and the unequal distribution of minerals and humus, the composition, texture, and depth of soil varies greatly from place to place.

Soil formation is a slow process. Life as we know it could not exist without soil. Therefore, soil is a valuable natural resource and should be conserved.

An exposure of soil on a cliff, bank, or gulley reveals layers of soil called a soil profile. A complete soil profile includes topsoil, subsoil, weathered rock, and bedrock. Topsoil is used for cultivating crops. It receives materials and its color from leaching of the topsoil. The underlying rock provides the parent material from which soil is made. Bedrock varies greatly in type and depth and greatly affects the soil type. The climate of an area has a profound effect on the nature of the soil formed there.

Life History. Life on earth has changed through the ages. The history of life is told in the fossil remains of ancient plants and animals. Life forms have changed greatly over billions of years. Some species have remained virtually unchanged for millions of years. Other forms are continually changing as they adapt to their environment.

Fossils. Fossils are the remains and traces left by dead organisms. Fossils include preserved bodies, parts of bodies, marks, footprints, and artifacts. Fossils were formed in the following ways:

> Unaltered remains. Soft body parts have been preserved by freezing. Wooly mammoths have been uncovered in Siberia and Alaska. Some entire bodies, flesh and all, were preserved, frozen in ice. In Mammoth Cave, Kentucky, there is an Indian body that has been preserved by the unusual environment of the cave. Hard parts of animals have been preserved in the famous LaBrea Tar Pits in Los Angeles, and closer by at Big Bone Lick, Kentucky.
>
> Altered remains. The Baltic Sea formed over an ancient pine forest. The pressure of the sea changed the pine resin to a yellowish rock called amber. Insects were caught in the gum-like material. Their soft bodies have long been distilled, but a carbonized copy of their bodies is preserved inside the amber.
>
> The Petrified Forest in Arizona is a fossil forest. Ancient trees were covered over with mud, sand, and volcanic ash. In some cases, the wood pores were infiltered by mineral matter. In other cases, the wood was slowly replaced by minerals forming mineral replicas of the trees. Bones of animals, such as dinosaurs, have also been petrified.
>
> Molds, casts, and imprints. Whole animal prints, as well as animal footprints, have been preserved as soft mud hardened. These are called molds and are "negative" prints. As molds are filled with mud and other mineral matter, solid duplicates of their shapes, called "casts," were formed. Casts are "positive" prints. Leaves falling on mud were covered with more mud. The leaves decayed, calcium carbonate (lime) filled the space and turned into limestone. These are called imprints.
>
> Other forms. Dung from ancient animals found in caves, and artifacts such as pottery, arrowheads, and ancient beaver dams are also classed as fossils.

The Geology of Cincinnati. The Cincinnati area has some of the most abundant, most diverse, and best preserved Ordovician fossils in the world. The upper major division of the Ordovician Period, in the United States, is called the Cincinnatian Series. Various layers within this series bear names derived from local communities and streets. These names indicate places where these rock layers are, or were, well exposed.

The Ordovician Period began about 500 million years ago and lasted about 70 million years. What is now Ohio was then a shallow, tropical sea which separated large islands to the east and west. There were no fish, but there were many sea creatures: sponges, corals, brachiopods, mollusks (snails, clams, cephalopods), arthopods (trilobites), crinoids, and other animal forms. These we know because of their fossils.

Sediments made of shell fragments of dead organisms, sand, silt, and mud settled to the bottom of the sea and built up the sea floor. These formed in strata (layers). Pressure of water and overlying sediments and cementation by minerals consolidated the sediments into rock. The bedrock of Cincinnati consists of layers of limestone, shale, and siltstone.

These rock strata have been uplifted by movement of the earth's crust, forming a broad arch called the Cincinnati Dome. This arch was planed by water and glaciers, forming level land. Erosion by streams carved out valleys, leaving hills of equal height and exposing a thick section of rock strata.

Glaciers have played an important role in local topography. They smoothed off the hills and filled the valleys with sand, gravel, boulders, and finely ground rock particles. Boulders of granite, for example, brought all the way from Canada, are found throughout the area.

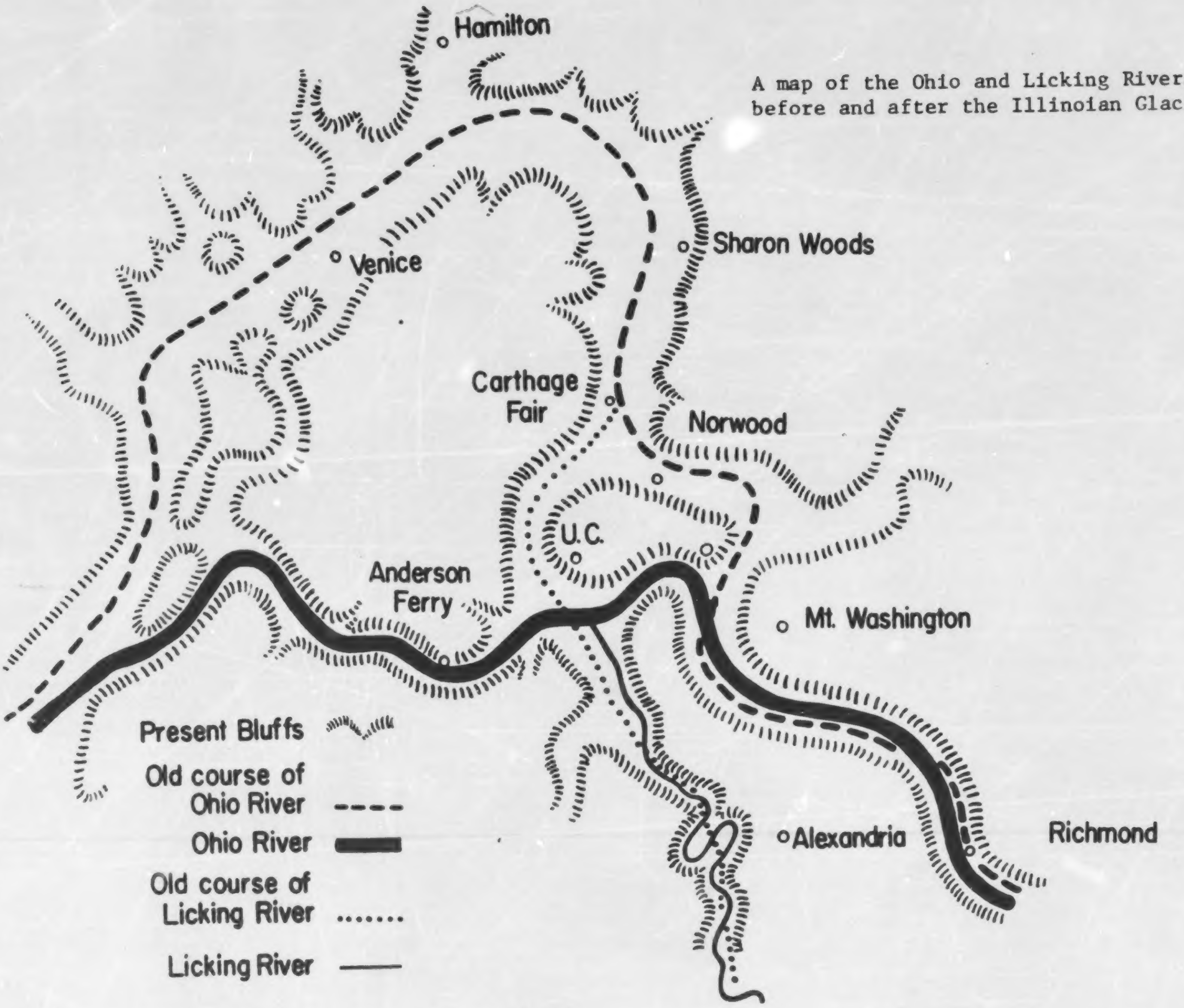
Glaciers have also changed the course of the rivers. The Ohio River once followed a path up the present little Miami to Newtown, then went through Norwood, northward to Hamilton, southward through Venice, until it reached the river where it is today. The Licking - Mill Creek was a northward flowing tributary to this pre-glacial river. The Illinoian Glacier, the second to the last glacier, dammed up the river changing it to its present course. Consequently, the Ohio River, an old, meandering river along most of its course, is a comparatively young stream in the vicinity of Cincinnati. It is a wide stream with a steep, narrow valley, whereas the old Mill Creek Valley is broad with a very tiny stream. This can be observed from high promontories surrounding Interstate 75 in the vicinity of the Western Hills Viaduct.

Rationale

The unit, "Geologic Processes," is designed to help students: (1) identify topological features and the forces that produced them; (2) describe properties of soil; (3) begin to conceive of long periods of time, such as thousands and millions of years; and, (4) identify and classify fossils.

It is important that children discover how natural forces bring about environmental changes. This understanding promotes conservation and the wise use of natural resources. Cincinnati geology offers abundant opportunity for children to observe the results of geologic processes. Children's natural curiosity about dinosaurs, ancient mammals, and fossils helps to make this unit very interesting and motivating.

A map of the Ohio and Licking Rivers before and after the Illinoian Glacier.


Hamilton
Sharon Woods
Venice
Carthage Fair
Norwood
U.C.
Anderson Ferry
Mt. Washington
Alexandria
Richmond
Present Bluffs
Old course of Ohio River
Ohio River
Old course of Licking River
Licking River

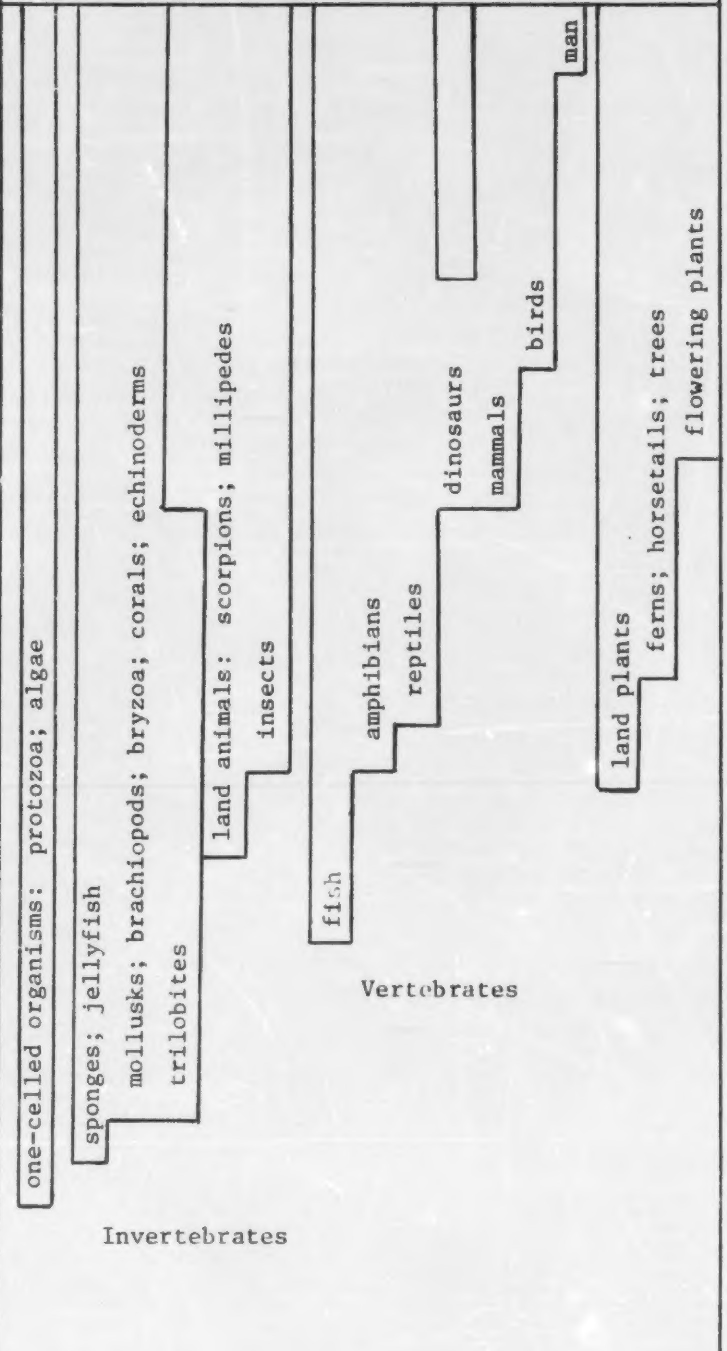
GEOLOGICAL TIME CHART

Era	Period	Millions of Years Ago	Geological History
CENOZOIC	Quaternary	Present 2	One of the dry times in the Earth's history Position of continents essentially the same as at present Ice Age - Four major glacial advances
	Tertiary	65	Mountain building: Alps; Himalayas, Sierra Nevadas; Cascades; Coastal Ranges Erosion of Grand Canyon Volcanism: Columbia Plateau lava flows Rocks of South Dakota Badlands formed
MESOZOIC	Cretaceous		Mountain building: Andes and Rockies Chalk deposited
	Jurassic		
	Triassic	225	Sediments formed on land in North America Dry climate Trees of Petrified Forest (Arizona) alive
PALEOZOIC	Permian		Appalachian Mountains uplifted North America rising above water; drying out period Glaciers in southern hemisphere
	Pennsylvanian		Coal and limestone being formed Ancestral Rockies rise
	Mississippian		Large inland seas
	Devonian		Dry climate Land sediments accumulated in Europe
	Silurian		Continents flat; seas shallow Coral reefs widespread
	Ordovician		Sediment deposited in Cincinnati in shallow sea Maximum submergence; two-thirds North America under water
	Cambrian	600	One-third North America under water Oldest abundant fossils with hard parts
PRECAMBRIAN		5000	Much erosion--mountains worn down Rocks exposed at the bottom of Grand Canyon formed Sedimentary rocks, no fossils Glaciers Land masses raised Volcanic eruptions Earliest rocks formed Origin of Earth

GEOLOGICAL TIME CHART

Era	Period	Millions of Years Ago
CENOZOIC Age of Mammals	Quaternary	Present
	Tertiary	65
MESOZOIC Age of Reptiles	Cretaceous	
	Jurassic	
	Triassic	225
PALEOZOIC	Permian	
	Pennsylvanian (Coal Age)	
	Mississippian	
	Devonian (Age of Fishes)	
	Silurian	
	Ordovician	
	Cambrian	600
PRECAMBRIAN		5000

Biological History


one-celled organisms: protozoa; algae
sponges; jellyfish
mollusks; brachiopods; bryzoa; corals; echinoderms
trilobites
land animals: scorpions; millipedes
insects
Invertebrates
fish
amphibians
reptiles
dinosaurs
mammals
birds
man
Vertebrates
land plants
ferns; horsetails; trees
flowering plants

Glossary of Concepts

Topographical Feature - A land or water formation on the earth's surface.

Geologic Process - Forces and conditions that cause changes in the rocks and soil that make up the earth's crust.

Fold - A wave-like bend in rock layers of the earth's crust.

Fault - A crack in the earth's crust.

Volcano - An opening in the earth's crust from which melted rock inside the earth flows; the mountain formed by this action.

Volcanism - Characteristic activities of a volcano, such as spewing hot ash and lava, erupting with great force.

Mountain - Any natural surface that rises to a noteworthy height above its surroundings.

Fault Block Mountain - A mountain formed by the listing of the earth along a fault line.

Dome Mountain - A mountain formed by an uplift.

Residual Mountain - A mountain that remains after the surrounding area is eroded.

Earthquake - A disturbance in the earth's crust; a regular wave-like motion transmitted through the earth in all directions caused by the slipping of rock layers.

Seismograph - An instrument that measures the strength of earth vibrations and earthquakes.

Weathering - The mechanical or chemical breakdown of rock material into fragments.

Erosion - The weathering and transportation of rock and soil by water, ice, and wind.

Deposition - The depositing of rock and soil by water, ice, and wind.

Land Form - A topological feature composed of land, such as a mountain or an island.

Glacier - A hugh mass of ice covering part or all of a continent or a mountain valley.

Moraine - An accumulation of stones, sand, and soil left by a glacier.

Soil - The top covering of the earth's crust above rock layers.

Topsoil - The uppermost layer of soil suitable for cultivation.

Subsoil - The layer of weathered material which underlies the topsoil.

Dinosaur - An ancient reptile form that lived in the Paleozoic Era; terrible lizard.

Extinction - The death of a species of plant or animal.

Fossil - Remains and traces of dead organisms.

Rock Strata - Layers of sedimentary rock formed at different times.

Investigations

Instructional Objective	Concepts
Given direct observation and pictures, identify topographical features by name.	Topographical feature

Materials needed:

study prints, land form models, filmstrips, films, and reference books
magazines
art supplies

Learning activity:

Use all types of media to show students pictures of land forms and bodies of water. If available, have them work with commercially-made land form models. Have them name and describe each model. Introduce the concept of topographical feature. Provide students with magazines and other sources of pictures and have them make a bulletin board display of topographical features. Let them draw pictures or make paper mache models of various land and water forms. Take a tour of Cincinnati and have students identify local topographical features.

Instructional Objective

Given appropriate materials, demonstrate how the earth's crust folds and faults.

Concepts

Geologic process
Fold
Fault

Materials needed:

different colors of modeling clay
3 or 4 large magazines

Learning activities:

1. Have students do the following demonstration.

   Place three magazines, one on top of the other, on a smooth table top with the magazines facing you just as though you were about to read them. Imagine that the magazines and their pages are layers of rock within the earth.

   Place your hands on either side of the pile of magazines and move your hands together. Your hands make a sideward pressure representing the pressure in the earth. What happens to the magazines? The folds of the magazines represent mountains made by the folding of the surface of the earth.

   Have groups of students place different colors of clay on each other so that they form layers. Push on ends of layers so that they bend and form a fold.

2. Make another set of layers by placing different colors of modeling clay on top of each other. Cut through the layers with a knife. Push on both ends until the cut ends slide against each other and form a fault.

3. Introduce the concept of "geological process." Identify folding and faulting as geological rpocesses. Encourage students to identify other forces that shape and change the earth's surface.

Instructional Objective

Given appropriate materials, demonstrate and explain how volcanoes are formed and how they erupt.

Concepts

Volcano
Volcanism
Geologic Process

Materials needed:

medium sized funnel or the stem of a coffee pot
pan
water
hot plate or Bunsen burner
modeling clay
art supplies
sand
newspaper
reference books and other media

Learning activities:

1. Show films and filmstrips of volcanoes erupting. Compare the properties of active, dormant, and extinct volcanoes. Have students use reference books and report on the formation of volcanoes. The formation of the Hawaiian Islands is an excellent example of the life cycle of volcanoes.

2. Set the large end of the funnel or the stem of the coffee percolator in a pan of water. Build a cone of modeling clay around the stem. Do not cover the opening at the top. Set the pan on the hot plate or over a Bunsen burner or alcohol lamp. Heat the water until it erupts from the opening at the top. Discuss what causes the eruption. Squeeze a piece of clay thin with your fingers and place it over the opening and repeat the experiment. Discuss what happens to the clay covering the opening. Compare the processes you observe in this experiment with those of a volcanic eruption.

3. Have students use reference books and other media to find different types of volcanoes. Have them draw pictures or make paper mache models of them. Have them pour sand on pieces of newspaper to show how cinder cones are formed. Have them draw cross sections of volcanoes and describe how they erupt.

4. Discuss "volcanism" as a geologic process. Have students locate the volcanic regions of the earth on a map.

Instructional Objective	Concepts
Given reference material, classify mountains by the way they were formed.	Mountain Fault block mountain Dome mountain Residual mountain Volcano

Materials needed:

reference books and other media

Learning activities:

1. Have students identify all the mountain ranges of the United States and the other major mountain ranges of the world. Let them use reference books and other media to classify these ranges by the way they were formed. Include volcanic, fault block, dome, folded, and residual mountains.

2. Have students draw a large map of the world, include the major mountain ranges and color code them by formation. Have them look for patterns concerning the location of various types of mountain ranges. This map may also be used to add other features later, such as earthquake zones.

Instructional Objective

Given appropriate materials, demonstrate how earthquake waves are measured.

Concepts

Earthquake
Seismograph

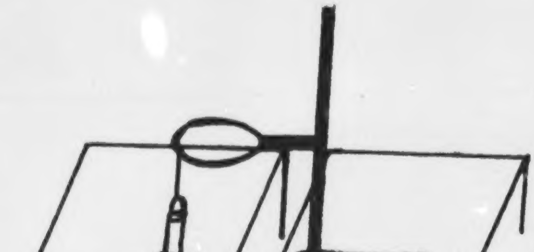
Materials needed:

- ring stand with ring
- 2 desks or tables
- twine
- roll of paper 15 cm x 100 cm
- pencil
- weight (lead or iron)
- masking tape

Learning activity:

Move the desks or tables so that they are a few centimeters apart. Put a ring stand on one table or desk so that the ring or support extends over the other table or desk. Fasten a weight near the point of a pencil with masking tape and attach a piece of twine to the eraser end of the pencil. Tie the other end of the string to the ring or support of the stand so that the point of the pencil touches the table when hanging freely.

Put marks along the edge of the paper an equal distance (5 cm) apart. Number these marks. Place the paper on the table or desk under the pencil point so that it can be pulled along evenly and smoothly. As the paper is pulled along under the pencil, have someone bump the table when certain marks are passed. The strip of paper should show a record of the earthquake that your seismograph has made.



Instructional Objective

Given appropriate materials, demonstrate weathering.

Concepts

Weathering

Materials needed:

- sandstone
- plastic tumbler
- water
- freezer
- seeds
- soil
- containers
- rocks and pebbles

Learning activities:

1. Soak a piece of sandstone in water for 6 hours. Observe and record changes. Freeze the piece of sandstone overnight. Observe and record any changes. Wrap the frozen piece of sandstone in a cloth. Do the same to a fresh piece. Strike both with a hammer. Observe and record the results. Discuss the comparison of the two samples. Lead the students to identify the variables that made the difference. Ask the students to state what effect water and temperature have on rock.

2. Take a field trip through the community and look for evidence of weathering. Encourage students to look for examples of the effects of water and temperature on buildings, sidewalks, road surfaces, and exposed banks.

3. Have students plant several seeds in a container of soil mixed with rocks and pebbles. Have them predict what will happen, record observations, and compare the predictions with the recorded data. Ask students if they think a growing plant could split a rock and have them give evidence to support their answers.

Instructional Objective	Concepts
Given a stream table, demonstrate (1) the formation of rivers and (2) the changing of topography by streams.	Erosion Deposition Land form

Materials needed:

long plastic tray
water
tin can with holes in the bottom
sand
large bucket or tub

Learning activities:

1. Place sand in one end of a long plastic tray. Let water drip onto the sand through a sprinkler made from a tin can. Have students observe and describe the action of the water. Have them observe stream development. Note how the stream cuts first deep into the sand and then how the banks erode and the stream bed widens. The water will also transport the sand and redeposit it into a delta at the mouth of the stream. Let the water flow over the end of the tray and catch it in a large bucket or tub.

2. Let students experiment with this apparatus to make other land forms. Rocks and other materials can be used as obstructions. Use this activity to help students identify land forms, such as islands, peninsulas, arches, columns, valleys, residual hills, and lakes.

Instructional Objective

Given appropriate material, identify and demonstrate the effects of erosion.

Concepts

Erosion
Glacier
Moraine

Materials needed:

2 plastic trays
sand
soil
sod
glass jars with lids
rocks and pebbles
water
milk cartons
clay
electric freezer
reference books and other media

Learning activities:

1. Take students on a walk through the community. Have them identify evidence of erosion and suggest ways to stop it. Encourage students to conduct a conservation project to prevent soil erosion.

   Have students demonstrate ways to prevent soil erosion. Have students put soil in one plastic tray and sod in another, spray water on each one and compare the results.

   Have students check reference books and other media to find other ways to prevent erosion. Let them draw and display pictures that illustrate these.

2. Have students observe the abrasive effects of erosion by shaking pebbles in jars of water. Let each child take a turn shaking a jar until the jar has been shaken for several hours. Ask: "How long do you think it would take to make the rocks worn down in nature? What do rocks from gravel pits look like? What made them that way? How were gravel pits formed?" Have students use reference books to find answers to these questions. If possible, visit a local gravel pit.

3. Have students report on the work of streams, wind, and glaciers. Let them use maps to study ways streams and glaciers have affected the Cincinnati area.

4. Have students demonstrate some of the effects of glaciers as follows:

   Place a handful of sand, soil, rock and pebble mixture in a milk carton. Put in enough water to cover the mixture. Freeze it. Put in another handful of the mixture. Cover with water and freeze again. Continue the process until the carton is filled half way.

   Peel the milk carton from the ice with the mixture. Put the sheet of clay in a plastic tray. Move the block of ice over the clay. What happens to the clay?

   Let block of ice remain on the clay. Raise pan in a tilting position and allow ice to melt. Tilt the tray and allow the ice to melt. Note the moraines that are formed. Describe them.

Instructional Objective	Concepts
Given a variety of soil samples, compare their properties.	Soil

Materials needed:

- soil samples: loam, sandy soil, clay soil
- hand lenses
- data sheets
- shovel
- plastic bags
- jars
- paper
- tape
- test tubes
- water
- funnel
- filter paper
- beaker

Learning activities:

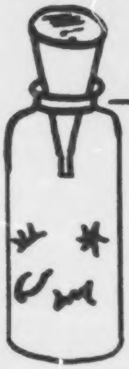
1. Provide students with small samples of loam, sandy soil, and clay soil and have them list observable properties of each. Have them also list the objects found in each sample. Let them use hand lenses to observe the small particles in the soil. Use a data sheet similar to the one below to record information.

Type of Soil	Properties	Objects
loam	black and brown moist smooth	sand dirt sticks soft plant materials
sandy soil		
clay soil		

After students have completed their records, have them compare the soils by giving their similarities and differences. Have students bring in soil samples from home, compare them with the samples they investigated at school, and classify them as loam, sandy soil, or clay soil.

2. Have students examine larger samples of soil. Place one or two shovelsful of soil into a large plastic bag. Have students examine the sample for organic and inorganic material. Have them separate various kinds of materials, placing them in plastic bags or small jars. Use samples of soil from a field, a wooded area, an eroded area, and a garden and have students compare the objects they contain and the properties of the soil.

   Make a paper funnel and place inside a jar. Attach the funnel to the jar with tape. Place a soil sample in the funnel and place a 75 watt bulb about 10 cm above the funnel. The living organisms in the soil should be driven into the jar by the bright light and intense heat. Have students take a census of living organisms found in various soil samples. Have them identify the type of soil that had the most organisms and name ways the organisms help the soil.



Seal funnel to jar with tape.

3. Have students compare the ability of various types of soil to hold water. Use the following methods.

   a. Measure equal quantities of loam, sandy soil, and clay soil into each of 3 test tubes. Pour water slowly from a graduated cylinder into one test tube at a time. Keep pouring until water stands above the height of the soil. Record the amount of water each type of soil absorbed.

   b. Prepare filter paper in a funnel. Moisten. Place the filter paper into the funnel. Moisten the filter with water so it adheres to the funnel. Place funnel over an iron ring or over a tumbler or bottle whose mouth is smaller than the funnel. Measure 2 tbs. of each type soil into the filter. Pour equal amounts of water into each sample, measure, and compare the amount that flows through.

Instructional Objective	Concepts
Given sedimentary rocks and organic material, demonstrate the formation of soil.	Soil formation

Materials needed:

rocks
hammers
organic materials (leaves, sticks, dead insects, etc.)
containers
suitable surface for pulverizing rock
seed
reference books and other media

Learning activity:

Provide students with the materials listed above or have them collect their own materials. Have them use these materials to make soil. Let them plant seed in their soil to see if it will grow. Have each student list the amount of each ingredient used.

Have students estimate how long it takes for one inch of soil to be formed naturally. Have them use reference materials to find out this and other pertinent information about the formation of soil.

Instructional Objective	Concepts
Given appropriate tools, obtain samples of soil and measure depth of the topsoil.	Topsoil Subsoil

Materials needed:

spade or garden trowel
ruler or yardstick
conduit pipe

Learning activity:

Ask the students how they might go about identifying and measuring the topsoil. Try their methods. Three ways to obtain topsoil are suggested below.

1. Find a place where you can have the permission to dig. Dig down until you find soil of different color and texture. Measure the top layer. Describe the soil in the top layer. Describe the soil in the second layer and compare the two layers. Discuss and develop the concepts of subsoil and topsoil.

2. Take a field trip to a bank where soil is exposed. Examine the soil layers, measure, and describe them. Help students identify topsoil, subsoil, and weathered rock layer.

3. Make a soil corer from a piece of electric conduit pipe about 60 cm long. Drill a hole through one end of the pipe. Insert a metal or wooden rod through the hole to make a handle. Push and twist the pipe into the soil as far as it will go. Remove the pipe. Push the soil out of the pipe with a dowel rod. Measure the topsoil.

Instructional Objective	Concepts
Given reference materials, investigate careers related to soil.	Soil careers

Materials needed:

reference books, films, filmstrips
the outdoors

Learning activities:

# Use reference materials, various media, and field trips to gather information about the following:

Methods of soil conservation
a. contour plowing
b. plantings
c. crop rotation

Careers in soil
- a. horticulture
- b. soil management
- c. turf and lawn care
- d. production of fertilizer
- e. role of county agents and other government agencies

Other topics
- a. soil belts
- b. soil testing
- c. economics of soil
- d. soil as a natural resource

Instructional Objective	Concepts
Given facts pertaining to the structure and habits of dinosaurs and the environmental conditions in which they lived, hypothesize the reasons why they became extinct.	Dinosaurs Extinction

Materials needed:

pictures and references of dinosaurs

Learning activity:

Have students list facts that are known about dinosaurs and their environment. Some facts that students may list are:

They were very large and heavy.
They had tiny brains.
Most of them were plant eaters.
They were cold blooded.
At the end of the Mesozoic areas, new mountains formed, swamps disappeared, the temperature became colder.

Have students make hypotheses about why dinosaurs became extinct and give reasons for their ideas. Discuss the meaning of "extinction." Relate the concept to the endangered species of today.

Instructional Objective	Concepts
Given an area rich in fossils and a fossil guide, collect and identify fossils.	Fossils Rock strata

Materials needed:

hand lenses
paper or plastic bags
paper and pencil
fossil guide

Learning activities:

Take students on a fossil hunt. There are many places around Cincinnati where fossils of the Ordovician period are in abundance. Hillsides, rocky fields, eroded areas are best. Look for whole fossils, but don't overlook fossils in rocks. Hand lenses help in scanning slabs containing fossils. Place all fossils from a specific strata in a paper bag and mark the location. Never mix fossils from different strata or locations. Be sure you have permission of the owner of the property before entering the property.

Clean specimens only with water and a soft brush. Never use sharp objects. Never paint of lacquer fossils nor use glue to mount them. Keep them in bags or drawers properly labeled. The label may include the date and location of the find and, if known, the name of the fossil and the name of the strata.

Have students use a guide to Cincinnati fossils to identify fossils and their strata. Help students learn to identify the seven most common fossils of Cincinnati: bryzoa, brachiopods, crinoids, gastropods, cephalopods, pelecypods, and trilobites.

Worthwhile collections are on display at the Natural History Museum and the University of Cincinnati Museum.

Instructional Objective	Concepts
Given a collection of fossils, classify them by their observable properties.	Fossils

Materials needed:

fossil collection
fossil guide
hand lenses
trays

Learning activities:

Provide individual children or small groups with a collection of fossils in a paper tray. Have them observe and describe the physical properties of each specimen. Let them classify the fossils by their preperties.

Have pupils make inferences and classify the fossils by the following:
a. How they were formed (are they imprints, molds, casts, or petrified?)
b. Where they were found (give geographic location)
c. Whether they were plants or animals
d. Whether they have any known relatives today
e. The type of environment in which they lived

Instructional Objective	Concepts
Given reference sources and an assigned topic, find information and report to the class pertinent information about ancient life.	Fossil Topographical feature

Materials needed:

books, filmstrips, pictures, and other media
clay, paste, boxes, paper, and other art materials
geologic time charts

Learning activities:

# 1. Visit the Natural History Museum or the University of Cincinnati Museum. Also, view the city from a high promontory to observe the evenness of the hills and the width of the valleys. Help students appreciate the unique geological features of Cincinnati. Invite a geologist or an archaeologist to visit the classroom and discuss his or her work. Invite a "fossil-hound" to discuss local geology and the contribution of amateurs to the field of paleontology.

2. Have students choose some of the following suggestions for individual or group projects.

   a. Construct dioramas, mobiles, or murals depicting environmental conditions and life in each geological era.

   b. Make paper mache or clay models of prehistoric animals.

   c. Locate maps showing the geographic locations of areas where various rock strata are exposed. Identify the kinds of organisms that lived in the period represented.

   d. Prepare a book illustrating the story of a fossil from the death of the organism to its display in a museum.

   e. Organize a classroom museum consisting of fossils, replicas of dinosaurs, and artifacts of early life (pictures or actual remains).

   f. Simulate an archaeological dig.

   g. Use reference books and other media to find information on the following topics:
      the ice age
      the LaBrea tar pits
      descriptions of a particular prehistoric reptile or mammal
      the evolution of the horse, camel, and other animals
      how animals became extinct
      endangered species today
      the formation of coal, oil, or chalk
      theories of the formation of the earth
      geodetic surveys

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AIR AND WATER

Background

Air. Air is a gaseous material. It has all the properties of a gas. It has weight, takes up space, can be compressed, exerts pressure, can absorb water, expands when heated, contracts when cooled, and is in constant motion.

Air is a mixture of gases. Its content of volume is approximately 78% nitrogen, 21% oxygen, and 1% other gases. It also contains dust and varying amounts of water vapor.

The amount of vapor air can contain increases with temperature, and decreases with pressure. Air over water will contain more water vapor than air over land.

Water. Water may appear in solid, liquid, or gaseous phases depending upon its temperature. Water is found in large quantities on the earth's surface. Approximately 2/3 of the earth's surface is covered with water. Water soaks into the soil and is trapped beneath the earth's surface. Water soaks into the soil, loose gravel, and porous rock. Water will continue to sink into the soil until it hits impermeable (non-porous) rock, or until the soil becomes saturated with water. Water found in soil, gravel, and porous rock is called ground water. The upper level of ground water is called the water table.

Water has interesting properties. Being a liquid it cannot be compressed to any great extent but does exert pressure because of its weight. It expands when heated. It contracts when cooled, except below 4^oC. where it expands when cooled. This is important because ice, being less dense than liquid water, floats on top of ponds making it possible for fish and other water life to live beneath the ice.

Water is also an excellent solvent, dissolving minerals in the soil, making them available to plants and transporting them into the ocean.

The Atmosphere. The atmosphere is the gaseous part of the earth that surrounds and mingles with the solid and liquid parts. The ocean of air extends from the earth's surface to over 600 miles (960 kilometers) into space. Because of the earth's gravity, the air is most dense at the bottom, with an average pressure of 14.7 pounds per square inch at sea level. It gradually decreases with altitude.

The atmosphere consists of four major zones or layers. These can be identified by their properties.

Troposphere. The troposphere is the zone nearest the earth. It extends upward to approximately 10 miles (16 kilometers) at the equator and 5 miles (8 kilometers) at the poles. Most weather phenomena occurs in the troposphere. The temperature drops 1^oC. for every 500 feet (150 meters) of altitude. The temperature will vary from -90^oC. to 120^oC. or more. Ninety percent of the atmosphere is within the first ten miles (16 kilometers) above sea level.

Stratosphere. The stratosphere extends above the troposphere to an altitude of approximately 50 miles (80 kilometers).

Ionosphere. The ionosphere, extending from 50 miles (80 kilometers) to 120 miles (180 kilometers) above the earth's surface, is composed of several ionized layers of air. By reflecting radio waves it makes long distant wireless communication possible.

Exosphere. The exosphere extends from 120 miles (180 kilometers) upward to outer space. Traces of air may be found as high as 600 miles (960 kilometers) above the earth's surface.

Air Travel. Air travel is one of the most important means of transportation today. Airplanes can fly because the design of the wing is such that as it moves through the air there is greater pressure below the wing than above it. The propeller and the jet are two methods used to propel the craft through the air. The propeller moves the air in a screw-like pattern. The jet engine moves by rapidly expanding gases. Both work on the action-reaction principle.

Rationale

The activities in this unit provide a basis for the understanding of weather phenomena. This unit will help students (1) identify and describe the properties and interactions of air and water, (2) investigate the composition of the atmosphere at various levels, and (3) understand the principles of atmospheric flight.

Every child has experiences with air and water daily. Not only do air and water support life, they are also essential factors in transportation and weather.

Glossary of Concepts

Air	The mixture of gases that surrounds the earth.
Property	A characteristic and attribute of an object.
Compression	Reduction of the space a material occupies by applying pressure to it.
Weight	The force of gravity on an object.
Air Pressure	The weight of air pressing downward on the earth. The pressure exerted by the mass of air.
Water Vapor	The gaseous form of water.
Oxygen	The second most abundant gas in the air; a gas essential to life.
Expansion	The process of an object or a material becoming larger, taking up more space.
Contraction	The process of an object or a material becoming smaller, taking up less space.

Atmosphere	The gaseous part of the earth that surrounds and mingles with solid and liquid parts.
Action-Reaction	For every action there is an equal and opposite reaction. (Sir Isaac Newton)
Variable	An object, condition, or force that can influence the outcome of an event.
Bernoulli's Principle	Air pressure decreases as the speed of moving air increases.
Phase of Matter	A form or state of matter, solid, liquid, or gas.
Density	Mass per unit of volume.

Instructional Objective	Concepts
Given a sample of air, describe its properties.	Air Properties of Air

Materials needed:

plastic bag
plastic or glass tumbler
1 gallon aquarium (plastic shoe box)
paper towel
cork stopper

Learning activities:

1. Ask the pupils to name the properties of air. Make individual lists and a class list. Stimulate and guide thinking by asking questions as needed. Introduce words such as clear, colorless, odorless, tasteless, if necessary.

2. Provide each child with a clear, plastic bag, and let them fill them with air. Also, fill a large plastic bag (garbage bag) with air. Now they can see that air can support weight, is springy (elastic), takes up space, makes the bag keep its shape, and the like.

3. Let the students explore the interactions of air and water by using a tumbler (or a vial) and a container of water. A one gallon aquarium or plastic shoe box will do well. Have them record their observations, or report them to the class. Provide them with a paper towel and a cork stopper. Ask them to see what they can do with them.

   Suggest the following:

   A. Invert the tumbler and push it down to the bottom of the container of water. What happens to the water level of the container? What is in the tumbler?

B. Place a wadded paper towel into the tumbler, invert it, and place it in the water. Does it get wet? Why? Why not?

C. Float a cork stopper in the water. Invert the tumbler over the stopper and push it to the bottom of the container. What happened to the stopper? Why?

Tilt the tumbler. What happened to the air in the tumbler? What happened to the water level in the tumbler? What happened to the water level in the container?

D. Let two children work together. Have them fill one tumbler with water, immerse it into the water in the container and invert it. Place a stopper in the tumbler. Invert a second tumbler and place it into the water. Put a stopper in it also. Pour the air from one container into the other. Describe what happens.

From the foregoing, children may observe that air floats in water; it takes up space, and it shows up as bubbles under water.

4. Since air makes bubbles in water, children should be able to tell if an object contains air. Let them test various objects for air by submerging them in water. Some objects, such as a leaf, may need to be left submerged in water over a period of time. Let them try such things as a sponge, a rock (especially sandstone), a seed, a sample of soil, different types of wood and many other objects.

Instructional Objective	Concept
Given appropriate materials, demonstrate that air can be compressed.	Compression

Materials needed:
one inflatable ball
air pump

Learning activity:

Pump up the ball until it is round. Ask children to describe how it feels. Pump some more air into the ball and have them describe it again. Ask them where the air is going and why you can keep pumping air into it. Introduce the word compress and define it, if necessary.

Instructional Objective	Concept
Given appropriate materials, demonstrate that air has weight.	Weight

Materials needed:

plastic bags

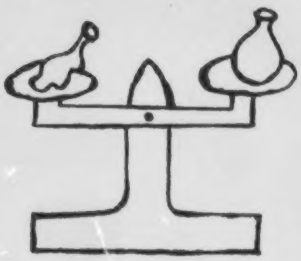
balance
balloons
inflatable ball
equal arm balance - or other sensitive balance
yardsticks
twine
paper clips
air pump

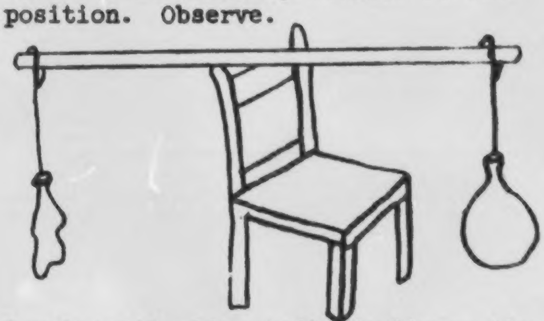
Learning activities:

1. Provide the materials above and instruct the students to see if they can weigh air. Ask them to give evidence that they have indeed weighed the air. After a student has weighed air with one method ask him to see if he can do it another way. They may experience difficulty in weighing air with one balloon or plastic bag on an equal arm balance. The two balloon method may be easier to verify with evidence. Two methods are suggested below.

   Two balloon method: Place one balloon on each pan of an equal arm balance. Make necessary adjustments until it balances. Blow up one balloon, place it back in the pan and observe.

   Yardstick method: Bend paper clips to make hooks and place them on opposite ends of a yardstick. Hang two deflated balloons (or plastic bags) from the paper clips with twine. Place the center of the yardstick on the back of a chair and adjust the balloons until the stick balances. Remove one balloon, inflate it and return it to its original position. Observe.





2. Students may do the following investigation individually or the teacher may wish to use it as a class demonstration.

   Weigh the ball on the balance. Pump it up. Weight it again. Subtract the two results to find the weight of the air. Ask the students why the two results are different.

Instructional Objective Concept

Given appropriate materials, demonstrate that air has pressure.

Air Pressure

For the teacher. There are numerous demonstrations that show that air has pressure. Some of these are illustrated here for your information. Children can do some of these. Others, because of safety or scarcity of materials, the teacher may wish to demonstrate or have a child demonstrate.

Let the pupils explore what they can do in one or two class periods. Then as you demonstrate, perhaps the egg in the bottle or the collapsing can, introduce, define and explain air pressure. This is a good opportunity to reinforce the concept by letting children view a film, filmstrip or use reference materials.

Materials needed:

one gallon can with screw-on lid
heat source (hot plate)
water

Learning activities:

Place about 250 ml. of water in the can. (While it is heating on the hot plate, calculate the surface area of the can in square inches.) While heating the can on the hot plate, discuss with the class what is happening to the water and to the air in the can. (As the water boils, the air is being forced out by the water vapor in the can.) Place the lid on the can and allow it to cool. You may wish to hasten cooling by pouring water on the can.

Ask, "Why did the can collapse? Why didn't it collapse before it was heated?" Calculate the surface area of the can in square inches. Multiply this figure by 14.7 (round to 15 if you wish) to find the number of pounds of air pressure pressing on the can.

Materials needed:

tumbler
card
water

Learning activities:

Fill the tumbler with water. Place the card flat on top, hold it and invert it.

Calculate the area of the tumbler. If the air pressure is 14.7 pounds per square inch, how many pounds of air are pressing on the card?

Ask the students to predict what will happen if some of the water is poured out and the card is placed on it. Test the prediction. Pour out a little more water and try again.

Materials needed:

jar
candle
pan
water

Learning activities:

Secure a candle in a shallow pan or saucer. Pour water into the pan. Light the candle. Place the jar over the candle and observe carefully. Have pupils report all observations.

This demonstration is worthy of much investigation.

Some observations often missed are
  a. brightening of candle flame
  b. bubbles escaping under jar
  c. condensation forming on jar

The children will also notice the flame being extinguished, and the water rising in the jar. What force is causing the water to rise in the jar? Is this force a push or pull?

Materials needed:

1 quart milk bottle
1 peeled hard boiled egg
piece of paper (twisted)

Learning activities:

Light the paper and drop it into the bottle. Place the egg on top of the bottle and observe. Report all observations. The egg will dance for a moment and will drop into the bottle. Ask for inferences concerning why the egg danced and why it went into the bottle.

The air is warmed by the burning paper, expands and escapes. This causes the egg to dance. The burning also uses up the oxygen. Both of these events help reduce the pressure in the bottle so the air pressure forces the egg into the bottle.

Materials needed:

glass tubing (15 cm.)
1 hole rubber stopper
250 ml. flask (or larger)
red food coloring
straw
paper cup
water
canned soft drink

Learning activities:

1. Place a piece of glass tubing into the hole of a rubber stopper. (Lubricate with water and twist as you push gently.) Fill the flask with water. Color water with red food coloring so it can be seen better. Have a child suck on the tubing. Discuss why the water won't come up.

2. Let some children drink some water from a paper cup with a straw. Discuss the differences in the two demonstrations. Calculate the exposed surface area of the water in the cup. Multiply by 14.7 to find the number of pounds of air pressure pressing on the water.

3. Make a single hole near the edge of a soft drink can. Try to pour the water from the can. Ask why the liquid will not flow and what you would have to do to make it flow.

Materials needed:

suction cup
2 clean microscope slides
talcum powder
water

Learning activities:

Allow the students to experiment with a suction cup.

Let them experiment with a clean microscope slide. Provide them with a little talcum powder to place on the slide. Then let them use a little water. Ask why the materials behave as they do.

Materials needed:

1 yardstick (thin, wooden hardware store type)
sheet of newspaper
hammer

Learning activities:

Place the yardstick on a table so that less than half of it sticks out over the edge. Ask, "What will happen if some one strikes the yardstick with a hammer?" - the reply is obvious. Ask, "What do I need to do if I wish to break the yardstick with the hammer?" Someone will suggest that you weigh down the other end. Ask, "Will someone standing on it help?" Then say, "But I want to be sure so I'll use something heavier." Spread the newspaper over the part of the yardstick that is on the table. Smooth it carefully with your hands. Strike the yardstick sharply with the hammer a few inches from the table. Discuss.

Materials needed:

reference books
films, filmstrips
transparency

Learning activities:

Let the students find information about air pressure in books, and other media. Use a transparency or a picture from a chart or book that illustrates air pressure. Find definitions of air pressure. Discuss the various definitions. In discussing air pressure, use the analogy of stacking thousands of pillows atop one another. Which are compressed the most? Which are compressed the least? Ask, "If you could weigh a column of air that is 1 sq. in. in cross-section area, and 600 miles high, what would it weigh?" (14.7 pounds at sea level.) "If you were to start 1000 feet above sea level, would it weigh more or less than at sea level?"

Instructional Objective

Given reference materials and student resources, identify applications of the principle of air pressure and the use of compressed air commercially and in everyday life.

Concepts

Air pressure
Uses of compressed air

Materials needed:

reference materials
objects that use air pressure

Learning activities:

#1. Brainstorm with students to generate ideas about how air pressure and compressed air are used commercially and around the home. Make a list of occupations that use compressed air.

#2. Have students bring in examples of objects that use compressed air such as, air pumps, hollow balls, inflatable balls, air mattresses, syringes, and the like. Have them demonstrate how these objects use compressed air. The teacher may wish to demonstrate use of a pressure cooker.

#3. Let students use reference materials to investigate various types of pumps, fire extinguishers, air lifts and the like. They may wish to draw pictures or make models.

#4. Some students may wish to investigate consumer products and measure and/or calculate the amount of air in them. Problems may be posed such as:

How much air is in a bag of popcorn?
How much air is in a given sample of cotton candy?
What other products have air in them?

Instructional Objective

Given appropriate materials, demonstrate that air contains water vapor.

Concept

Water vapor

Materials needed:

ice cubes
water
cloth or sponge
plastic vial

Learning activities:

1. Let each student place an ice/water mixture in a plastic vial. Observe then what happens to the surface of the container. Ask, "What is the material? From where did it come?"

Discuss the children's hypotheses.

Introduce the word condense. Define it.

2. Pour out the ice/water mixture and observe. What happens to the water on the outside of the container? On the inside?

   Wet the blackboard with a damp cloth or sponge. Discuss that happens.

   Introduce the word evaporate and define it.

Instructional Objectives	Concept
Given appropriate materials, demonstrate that air contains oxygen.	oxygen

Materials needed:

- two test tubes
- two tumblers
- water
- two test tube clamps
- one-ring stand
- steel wool
- reference books

Learning activities:

1. Place a piece of wet steel wool into the bottom of a test tube. Invert it, clamp it to the ring stand and immerse it in water. As a control immerse a second tube without the steel wool into water in the same manner. Let it stand for 24 hours and observe what happens. (Water will rise in the tube containing steel wool. The steel wool will rust.)

   Ask the pupils to report every evidence of interaction in the demonstration.

   Ask, "Why do you think the water rose in the tube? Do you think there is any connection between the steel wool rusting and the water rising in the tube?"

2. Measure the amount of water in the tube. What fraction of the tube is filled with water? (If all the oxygen is used the water will rise to approximately 1/5 of the height of the tube.)

3. Let students use reference books to find additional information about oxygen and other gases found in the air. Make a chart or graph showing the various materials found in the air.

4. Light a candle. Place a jar over the candle and observe. Report all observations.

Light two candles. Place a fresh jar over one candle and the jar from the first demonstration over the second candle. Let the students predict what will happen.

Compare what actually happens to the predictions that were made. (One candle will go out quickly.)

Ask, "Why did one candle go out more quickly than the other?"

If the students don't know about oxygen, introduce the word and have them refer to books to find out what they can about it.

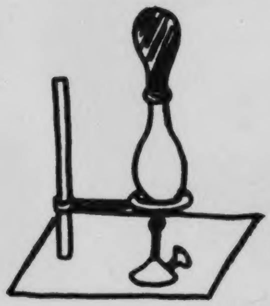
Instructional Objective	Concepts
Given appropriate materials, demonstrate that air expands when heated.	expansion contraction

Materials needed:

- a Pyrex flask
- a balloon
- a heat source
- a support for the flask or test tube clamps
- pop bottle
- pan
- hot plate

Learning activities:

Ask the children to predict what will happen when air is heated. Set up the apparatus as pictured below, heat the container, and observe. If the teacher feels this is too dangerous for the children to do, it may be done as a class demonstration. This can also be done with a pop bottle in a pan of water on a hot plate.



Lift the edge of the balloon, letting air escape. Ask the children to describe what happened. Let the flask or test tube cool. Observe what happens. Ask the children to hypothesize why the balloon entered the flask. Ask them how they might get it back out again and why that suggestion (heating it) might work.

A variation of this activity would be to show the students a flask or test tube that has a balloon inside it and ask them how they think that it was done. Let them test their hypotheses by experimenting.

Instructional Objective

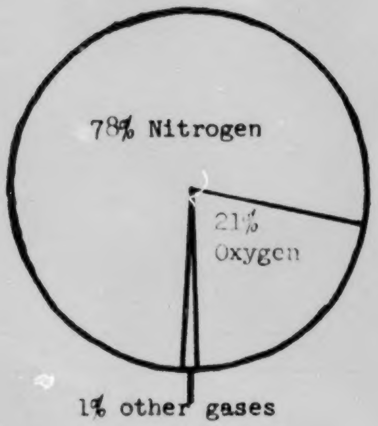
Given reference materials, construct a chart showing the composition of air.

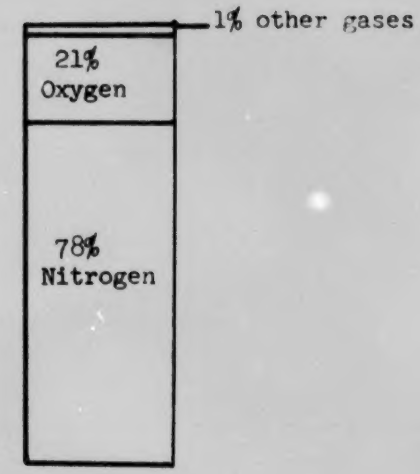
Materials needed:

reference books and other media
pencils, paper

Learning activity:

Instruct students to make a chart or graph showing the percentage of the various gases that make up air. Help them to devise a variety of ways to show this, such as a circle graph, a single bar graph or a simple data sheet.





Instructional Objective

Concept

Atmosphere

Given reference materials, find and report the names and properties of the four layers of atmosphere.

Materials needed:

chart or transparency
reference books
films, filmstrips

Learning activities:

1. This activity may be introduced in many ways. The class as a whole can view a transparency or a chart on the layers of the atmosphere. The teacher may wish to lead the class in a brainstorming session in which the students tell all they can about the chart. This may also be done in small groups, in pairs or individually. If one of these approaches is taken, the whole class should meet later for interaction and feedback.

# 2. Use the reference material to explore related topics. Students may look up information on each layer of the atmosphere. They may wish to find out who discovered these layers. Names they may wish to use are Auguste Piccard, Oliver Heaviside and A. E. Kennelly.

Instructional Objective	Concept
Given reference material, construct a chart showing the four layers of the atmosphere.	Atmosphere

Materials needed:

reference material
paper and art supplies

Learning activities:

1. Have students use the information they found to construct a chart. Although they have already seen such a chart in class or in books, this can be a valuable activity. The teacher may wish to help students to establish criteria for the construction of the chart. Criteria that might be considered are: scale, information to be included, a way to illustrate differences in pressure and temperature. There are some surprises that occur in temperature.

2. In addition to the usual methods of reporting, the teacher may wish to have the pupils construct a data sheet listing the properties of each layer.

Layer of Atmosphere	Altitude in Miles	Temperature in degrees F	Lbs./sq. in. Pressure	Phenomena or Events
Troposphere	5-10	-900 to 120°	14.7 - ?	Weather, Storms, Rain, etc.

# 3. Use reference material to investigate jet streams and their effect on air travel and weather.

Instructional Objective	Concept
Given appropriate materials, construct a balloon-powered jet craft.	Action-reaction

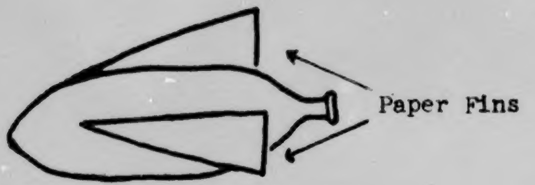
Materials needed:

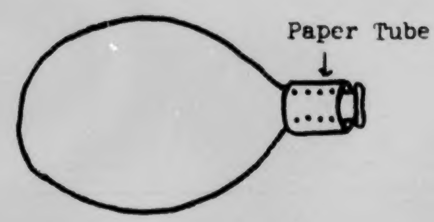
- balloon - cylindrical and round
- paper
- tape
- twine
- paper clips

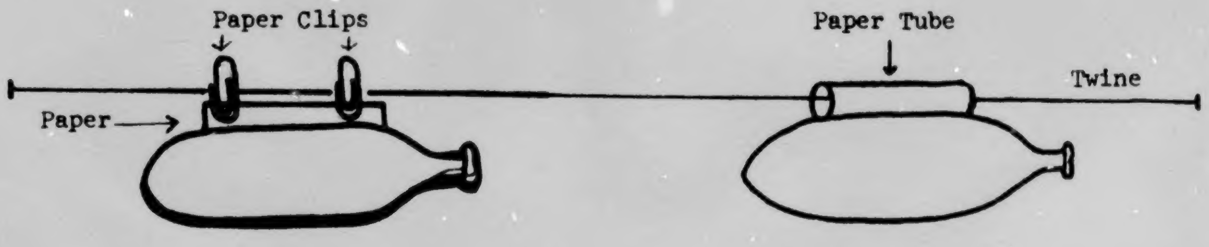
Learning activity:

Let students blow up balloons and release them. Ask them to describe the motion of the balloons. Provide the other materials listed above and instruct the students to try to control the direction of the movement in some way.

They may try fastening fins to the sides of the balloons and fastening paper tubes to the mouths of the balloons. They may also use a piece of twine stretched across the room as a track for a balloon-powered jet craft.







Instructional Objective	Concept
Given experiences with balloon-powered jet craft, apply the principle of action-reaction to the propulsion of air craft.	Action - reaction

Materials needed:

reference sources
pictures of jet engines
picture of airplane propeller
model of airplane propeller and rubber band (optional)

Learning activities:

# Provide materials and ask students to explain how aircraft are propelled. Include both propeller-type and jet-type aircraft. Have the students first try to explain without using reference sources then let them use reference sources to check, reinforce their ideas and to give them additional information.

Introduce the concept of action-reaction and help them apply this concept to the motion of aircraft.

Instructional Objective	Concept
Given appropriate materials, construct paper airplanes and identify the variables that affect their flight.	Variables

Materials needed:

paper
scissors

Learning activities:

1. Have students make paper airplanes and fly them. Suggest that they make tail flaps and rudders to try to control the motion of the paper plane. Discuss variables that affect the distance and direction of flight.

# 2. Have a contest. Give a prize for the paper airplane that flies the farthest and for the one that stays in the air the longest. Ask, "What do you call a person who designs an object to have specific properties or to function in a specific way?" Introduce the word engineer. Let students use reference material to find the names of other engineers involved in designing various components of aircraft.

Instructional Objective	Concept
Given materials used to demonstrate Bernoulli's principle, make predictions and test them by experiment.	Bernoulli's principle

Materials needed:

paper
2 balloons (round)
twine
3 x 5 card
wooden spool

Learning activities:

1. Instruct students to hold a piece of paper by two adjacent corners and allow the other end to fall down away from them. Ask them to predict what will happen when they blow across the top of the paper. Have them test their prediction.

2. Suspend two inflated balloons by pieces of twine so the balloons almost touch. Ask the students what will happen when they blow between them. Let them test their prediction.

3. Have students place a spool lightly on a 3 x 5 card. Ask them to predict what will happen when they blow gently through the spool - then test their prediction.

4. Introduce the term "Bernoulli's principle." Have the students try to state the principle in the form of an operational definition. Ask them why they think it works. Then suggest that they look up Bernoulli's principle in a reference source and compare their hypotheses with the explanation they find in the books.

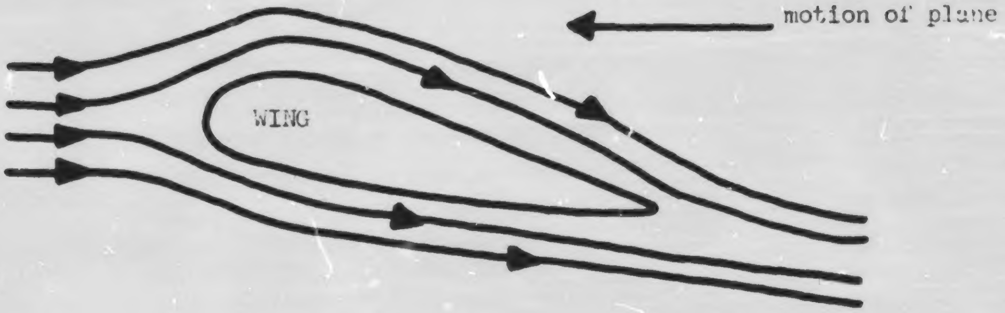
Instructional Objective	Concept
Given experiences illustrating Bernoulli's principle, apply that principle to explain the lift of an airplane wing.	Bernoulli's principle

Materials needed:

a picture or model of an airplane wing
reference sources

Learning activity:

# After students have completed the experiences illustrating Bernoulli's principle, show them a picture or a model of an airplane wing. Ask them to try to explain how an airplane wing provides the lift. They need to know that the air moving over the airplane wing reaches they rear of the wing at the same time as does the air flowing under the wing. Since the path above the wing is greater, the air moves faster.



Ask students to apply Bernoulli's principle to explain how the wing gets its lift. The students may wish to compare their ideas with the ideas in some reference sources.

Instructional Objective	Concept
Given reference material, describe methods of transportation in and through the atmosphere.	Air transportation

Materials needed:

reference books
films, filmstrips
other media

Learning activities:

# 1. Provide the students with a bibliography and suggested topics and help them find and report information on ways we use air and the atmosphere in transportation. Some topics that might be helpful are:

   a. How do automobiles use air?
   b. What does a carburetor do?
   c. How do aircraft fly? What are some different engines aircraft use?
   d. What is Bernoulli's principle? What impact did this principle have on the air travel industry?

   e. How do hovercraft work?
   f. What are some of the different kinds of lighter than air craft (balloons, derigibles) and how do they fly?
   g. Why rockets?

# 2. The teacher may wish for students to explore other related topics, such as:

   a. Occupations related to the transportation industry
   b. Problems of supersonic flight
   c. Environmental problems related to air transportation - pollution, energy crisis, conservation of natural resources, disposal of worn-out automobiles

# 3. Suggested field trips:

United States Air Force Museum
Wright-Patterson Field, Dayton, Ohio
Greater Cincinnati Airport

Instructional Objective	Concept
Given a sample of water and other appropriate materials, describe the properties of water.	Water property

Materials needed:

water
piece of wood
different kinds of paper
salt, sugar, flour
plaster of Paris

Learning activities:

1. Ask the students to name some properties of water. List these on a piece of chart paper or let each person make his own list.

2. Pass out water in a paper cup and make available other materials that can interact with water. Add other properties to the list above.

Instructional Objective	Concept
Given appropriate materials, (1) demonstrate the three phases of water; (2) demonstrate how heat affects the phases of water; and (3) demonstrate how heat affects ability of water to dissolve salt.	Phases

Materials needed:

test tubes (large)
tumblers
crushed ice
rock salt
thermometer
water
Pyrex beaker or metal pan
hot plate

Learning activities:

If feasible, allow the children to explore the different phases of water using the materials above. Some of the tasks or problems children might work on are given below.

1. At what temperature will water freeze? (Put water in test tube with thermometer, place in a salt/ice/water bath.)

2. At what temperature will water boil? (Place thermometer in pan of water and boil it.)

3. What variables affect the temperature at which water freezes and boils? (Add salt to water and try to boil and freeze the water.)

4. How does the temperature of water affect its ability to dissolve salt? (Measure the amount of salt that will dissolve in 50 ml.of water at different temperatures.)

5. Investigate the commercial products that are used to melt ice on roads and sidewalks (rock salt, sand). Develop a method for testing the effectiveness of these materials. What are the advantages and disadvantages of each? How do they work? How much does the city spend annually to remove ice and snow from the streets? What materials does the city use? Would other materials do the same job, be as safe to use and be as economical?

Consult a consumer publication for possible information on the products used for ice control.

Investigate products used in anti-freeze and summer coolants for automobiles.

Investigate the work of consumer product testing such as underwriters' laboratories, and consumer publications.

Instructional Objective	Concepts
Given appropriate materials, demonstrate the affects of heat on (1) the volume of water and (2) the density of water.	Heat Water

Materials needed:

2 ft. piece of glass tubing
water
food coloring
250 ml.or 500 ml.flask
hot plate

Learning activities:

1. Put a 2 ft. piece of glass tubing into a one-hole rubber stopper. Place the stopper firmly into a flask of colored water so that the water level is above the stopper. Heat on a hot plate and observe. Ask, "What causes the water to rise?"

   Ask, "What happens to water when it is heated? What happens to water when it is cooled?"

2. Place a container of water in a small container (not glass). Mark the water level and place it in the freezer. Ask, "What happens when water freezes? Will it contract or expand?" (Water begins to expand when cooled at 4°C.)

Instructional Objective	Concept
Given appropriate materials, compare the density of hot water to the density of cold water.	Density

Materials needed:

pan balance
2 tumblers
graduated cylinder
water
hot plate

Learning activities:

1. Show the students 2 tumblers of water, one hot (80°-90°C), and one cold. Make sure that each container has 50 ml. of water. Ask students which is heavier or whether they weigh the same. Record predictions. Place the cold water on one side of a pan balance and the hot water on the other side. Ask the students to state why the cold water was heavier. (Hot water takes up more space than cold water.)

2. If students do not know the word "density," introduce it, define it, and use it to describe the phenomena above. (Hot water is less dense than cold water. The molecules of hot water are farther apart than the molecules of cold water.)

Instructional Objective	Concept
Given reference materials and student resources, identify ways water is used commercially and around the house.	Uses of water

Materials needed:

reference material including consumer product publications

Learning activities:

#1. Brainstorm with students to identify the many commercial and domestic uses of water. Make a list of occupations that make use of water.

#2. Visit a water treatment plant and identify the different types of jobs needed to operate the plant.

#3. Identify consumer products that contain water. Discuss the following statements: "The more water you can sell the public the more money you can make." Read the labels. Compare the amount of water in various brands of the same kind of product. Where is water in the order of listed ingredients? (Items are listed on labels in the order of percentage of content from the highest to the lowest.)

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

1641	Water Cycle
622	Winds and Their Causes
952	Temperature and Wind
281	What Makes the Wind Blow?
1411	What Makes Rain?
951	Pressure and Humidity

Filmstrips

6949	Why Does the Wind Blow?

A-V Media Approved for Purchase

Filmstrips

Jam Handy

First Experiment With Air (5 Filmstrips)

- Air Is Real
- Living Things Need Air
- Air Is Everywhere
- Air Pushes Against Things
- Air Helps Things Float in Water

Heat (4 Filmstrips)

- How Heat Causes Expansion
- How Heat Travels

Jam Handy

Understanding The Atmosphere (5 Filmstrips)

Physical Characteristics of Air
What Is Air Pressure?
Composition of Air
Importance of Air in Nature
The Earth's Atmosphere

Society for Visual Education

True Book Physical Science (6 Filmstrips)

Air Around Us

Ward's Natural Science Establishment

Using Natural Resources (7 Filmstrips)

Water I
Water II

Sound Filmstrips

Coronet Films

Aerospace (6 Filmstrips/6 Cassettes)

The Story of Flight
How Airplanes Fly
Aircraft Engines: Piston and Jet

Eye Gate House

Earth Science (10 Filmstrips/5 Cassettes)

Atmospheric Currents

Meteorology (4 Filmstrips/2 Cassettes)

The Atmosphere

Popular Science Publishing Company

Conservation for Today's America (7 Filmstrips/4 Cassettes)

Water Conservation Today

Earth's Blanket of Air (1 Filmstrip/1 Recording)

Study Prints

- Instructional Supplements
  - Geology (6 Study Prints/Set)
    - Ground Water

Transparencies

- Hubbard Scientific
  - Geology
    - Ground Water
  - Meteorology Set I
    - Water Cycle

OBSERVING THE WEATHER

Background

Observing the weather requires the use of all senses. People perceive weather as various phenomena and conditions of the air that they can see, feel, hear, and sometimes smell. A description of the weather includes air temperature, wind speed and direction, humidity, cloudiness, precipitation, and air pressure. For some purposes, simple observations and simple descriptions are adequate, but for others, it is necessary to have fairly accurate measurement. For those, a variety of instruments are used.

Temperature. A thermometer is used to measure the temperature of the air. It is important that the thermometer be placed in the shade. A thermometer placed in the sun would continue to absorb the sun's radiation and become much warmer than the air. Most common thermometers are hollow glass tubes containing a liquid, either alcohol or mercury. Since liquids expand when warmed and contract when cooled, they can be used to measure temperature. Other types of thermometers work on the expansion and contraction of metal strips and coils. Although air temperatures are given in degrees Fahrenheit at the present time, increased use of the metric system will most likely result in the universal use of the Celsius scale.

Air Pressure. Differences in air pressure are caused by temperature, humidity, and the height of the air mass. Air pressure is measured with an aneroid or mercury barometer. An aneroid barometer contains an air tight disc-like metal box from which most of the air has been removed. As the air presses on the box, the flat side is depressed. This movement is transferred to a needle on the dial of the instrument, which is calibrated to indicate the amount of air pressure. A mercury barometer consists of a glass tube inserted into a cup of mercury. It measures the height of mercury the air will support. Air pressure is usually reported in inches of mercury or in millibars. A millibar is 1/1000 of a bar. A bar is 29.53 inches of mercury at sea level.

Humidity. The relative humidity is measured with a hygrometer. This instrument consists of a wet bulb thermometer and a dry bulb thermometer. A sling psychrometer is a hygrometer in which the wet thermometer is slung through the air on a chain. The difference in the two readings will vary with the amount of moisture in the air and temperature. Evaporation has a cooling effect. If the humidity is low the evaporation will be fast and the cooling effect will be great.

The relative humidity is read from a chart and is reported in per cent. One hundred per cent humidity means the air is saturated with moisture and cannot evaporate more moisture. The two readings will be the same. A relative humidity of 75% means the air contains 75% of the moisture it is capable of containing at that temperature.

Relative humidity and temperature together affect comfort. A person can be rather comfortable at a temperature of 80° if the humidity is low, but feel very warm and uncomfortable if the humidity is high.

Wind. Both wind speed and direction are important in affecting our weather. Wind is caused by differences in temperature between two air masses. Wind speed is measured with an anemometer. An anemometer consists of three or four cup-like objects that spin in the air. Wind speed is reported in miles per hour. Wind speed can also be estimated with the Beaufort Wind Scale. Wind direction is determined with a wind vane. The wind vane points into the wind. The direction from which the wind is blowing is the direction reported.

Clouds. There are three main types of clouds: cirrus, cumulus, and stratus. There are many combinations and varieties. Rain clouds are called nimbus clouds. A particular cloud formation may be called nimbo-stratus or cumulo-nimbus. Sky cover may be described as being clear, partly-cloudy, or overcast, or may be reported as the per cent of the sky covered.

Rainfall. Rain is measured with a rain gauge. Rain is collected in a cylindrical container and measured with a scale calibrated to hundredths of an inch.

Water Cycle. Water is a major factor in weather. The earth's water supply is a well conserved system. Little, if any, is lost and little, if any, is made. Water is constantly being moved from one place to another and changed from one form to another. The changing of water from a liquid to a gas and back again into a liquid, or solid, is called the water cycle.

As water is heated to its boiling point, it is changed into water vapor, an invisible, colorless gas. Air is capable of absorbing water vapor. Warm air can hold more water vapor than can cold air. As air containing water vapor is cooled, it gives up some of its moisture.

Water that has been condensed in the form of clouds or in the form of a white substance seen rising from the teakettle is often incorrectly called vapor or steam. Water vapor and steam are water in gaseous form and are invisible. Clouds and the "white stuff rising from a teakettle" are formed of tiny droplets of liquid water and, hence, are clearly visible.

The water cycle can be traced through three processes - evaporation, condensation, and precipitation.

Evaporation. Evaporation is the process in which a liquid is changed into a gas. Water is evaporated from the earth, land, bodies of water, and living organisms. The rate of evaporation increases with temperature. The higher the temperature, the faster water will evaporate. Evaporation is also determined by the humidity of the air. The drier the air, the faster water will evaporate. When the air is saturated with moisture, no more water will evaporate.

Condensation. Condensation is the process in which a gas is changed into a liquid. Water vapor condenses into liquid water when it is cooled. When air containing water vapor is cooled, it gives up its moisture. The vapor is condensed in various forms depending upon other existing conditions. These forms and the conditions under which they are formed are as follows.

Clouds. Water condensed as tiny droplets in the atmosphere when the water vapor in the air is cooled below the dew point.

Fog. Water condensed as tiny droplets near the earth's surface.

Dew. Water condensed on cold objects such as plants, rooftops, and rocks.

Frost. Vapor condensed on objects when the air is below the freezing point of water, 0°C - 32°F.

Snow. Water condensed in the atmosphere when the air is below the freezing point of water.

Precipitation. Precipitation is some form of water falling to the earth from the atmosphere. Forms of precipitation and the conditions under which they are formed are as follows.

Rain. Water falling to the earth in liquid drops. Vapor condenses and collects around particles of dust, smoke, or ice to form raindrops.

Snow. Solid crystals of ice that condensed from the atmosphere below 0°C - 32°F.

Sleet. Frozen rain; formed when rain freezes on the way down.

Hail. Hail is a ball of ice formed as layers of water collect and freeze. Hail is formed during thunderstorms when strong currents of air carry water high into the air where it freezes. It falls into a layer of warm, moist air where another layer of water condenses on it. This is repeated many times until a ball of several layers of ice is formed.

The water shortage is a problem of supplying fresh, usable water in the right place when it is needed. As water is naturally distilled by evaporation and condensation, it is purified. Water becomes contaminated as it falls through polluted air, drains through polluted soil, into polluted lakes, and flows through polluted streams.

Rationale

The unit Observing the Weather is designed to help students (1) observe and describe weather conditions, (2) understand and identify the various phases of the water cycle, (3) identify conditions of the air and the methods of measuring them, and (4) record and interpret weather information.

Weather is an extremely important factor in human life. It affects the work of the farmer, the seaman, the airline industry, military operations, the way we dress, our recreation, and many other aspects of life.

Glossary of Concepts

Weather	The condition of the atmosphere at a specific time and a specific location.
Season	A time of year characterized by its weather conditions.
Weather Elements	Specific weather conditions of air and moisture which make up weather.
Temperature	How hot or how cold the air is.
Air Pressure	The force of air pressing on the earth. The pressure exerted by the air in all directions.
Relative Humidity	The amount of water vapor in the air compared to the amount the air can hold when saturated.
Wind	Moving air.
Cloud	Tiny droplets of water or tiny particles of ice that condense in the atmosphere.
Precipitation	The process of water, in some form, falling to the earth from the atmosphere.
Thermometer	An instrument that indicates temperature by measuring the expansion and contraction of a liquid or a metal band.
Barometer	An instrument used to measure air pressure.
Hygrometer	An instrument used to measure relative humidity.
Wind Vane	An instrument that indicates wind direction.
Anemometer	An instrument used to measure wind speed.
Rain Gauge	An instrument used to measure rainfall.
Beaufort Wind Scale	A scale used to estimate the speed of the wind by observing the effects of wind on smoke, flags, and trees.
Evaporation	The process of a liquid changing to a gas.
Condensation	The process of a gas changing to a liquid or solid.
Dew	Water that condenses on cold objects.
Frost	Crystals of ice that condense on objects.
Dew Point	The temperature at which water vapor in the air will condense.
Fog	Tiny droplets of water that condense near the earth's surface.

Rain	Drops of liquid water formed when water vapor condenses around a particle of dust, smoke, or ice, then falls to the earth.
Snow	Ice crystals, usually six sided, that have condensed in the atmosphere.
Sleet	Frozen rain.
Hail	Balls made of layers of ice that fall to the earth from the atmosphere.
Water Vapor	Water in the form of a gas.
Steam	Water in the form of a gas formed by boiling. Water vapor at a temperature above the boiling point of water.
Water Cycle	The interchange of water absorbed into the air as vapor and returning as a liquid or solid.

Investigations

Instructional Objective	Concepts
Given the present time, location, and pictures of outdoor scenes, describe the weather in terms of observable conditions.	Weather Seasons

Materials needed:

- access to the outdoors
- dictionaries
- pictures of outdoor scenes
- paper and art supplies
- books, filmstrips, and other media

Learning activities:

1. Take students outdoors and have them describe the weather. You may ask, "What is it like outdoors today? Tell me all you can about it." Record responses for future reference.

   Ask, "What are you really talking about when you talk about the weather? What is it that is hot or warm or cold or damp?" Lead the students to discover that what they are describing is the air. Have them look up the definition of weather in a dictionary or glossary.

2. Use flat pictures, study prints, filmstrips, or a sound film to show pictures of outdoor scenes Have the students describe the weather in the pictures. Ask them to give evidence for their opinions.

3. Ask the children to describe how the weather varies from season to season. Some suggested questions to use are: "What is the weather like in the spring? Are all spring days warm? Does it ever frost or snow in the spring? In what season are we most likely to have hail? tornadoes? thunderstorms? snowstorms? How do weather changes affect people's work, transportation, and recreation?"

   Have students draw pictures of scenes depicting each of the four seasons.

   Reinforce the students' descriptions with information from books, films, filmstrips, and other media. Let them continue to describe the weather throughout the unit to improve their ability to do so. Evidence of improvement will be indicated by the correct use of words introduced during the study, the significance of specific information included, inferences and interpretations of phenomena observed, and the attempt to make predictions from observations.

Instructional Objective

Given appropriate materials and experiences, identify and describe important elements of weather.

Concepts

Weather elements
Temperature
Air pressure
Relative humidity
Wind
Precipitation
Clouds

Materials needed:

reference books and other media
newspaper
weather maps

Learning activity:

Using the experiences from the preceding activities, generate a list of important elements of weather. Have students listen to newscasts and bring in newspaper weather maps and reports. Make a class list of the major aspects of weather. Have students read or view films and filmstrips to find additional information. Have them prepare descriptions or definitions of each weather element to be presented orally or in writing. Future descriptions of weather should include most or all of these elements.

Instructional Objective

Given appropriate materials, identify variables that affect temperature.

Concepts

Temperature
Thermometer
Variable

Materials needed:

thermometers
paper; black, white, and colored

Materials needed: (continued)

water	pans of soil
alcohol	snow

Learning activities:

1. Let individuals or pairs of students find and record the temperature at different places in the room, in the school, and outdoors. Record these temperatures in both Fahrenheit and Celsius scales.

Location	Temperature	
	F°	C°
Room -		
floor level		
ceiling level		
center of room		
by the windows		
glass of water		
In School -		
cafeteria		
library		
hallway		
Outdoors -		
in the sun		
in the shade		

Help students identify the variables that affect temperature by comparing temperatures on this chart.

2. Make a class histogram of all the temperatures reported by the children. Draw a numberline using the range of temperatures reported. Place an "X" or other mark for each temperature given. Have students propose reasons for the variation in temperature.

3. Ask students to compare the speed of evaporation between alcohol and water. Let them experiment to find ways to do this quickly and effectively. They may dip their fingers into the liquids and wipe them on a paper towel, their desk top, or the chalkboard.

   Ask them to dip their fingers into the liquids, wave them in the air and report what they feel. Have them dip thermometers into the liquids, wave them in the air and compare the temperature readings. Have students describe the relationship between the rate of evaporation and the temperature.

# 4. Have students determine the relationship between the color of an object and its temperature.

Instruct the students to place thermometers under sheets of paper of various colors. Place in direct sunlight for 2-3 minutes. Record the temperatures obtained for each color.

Let students place squares of black and white paper alternatively on snow to form a checkerboard pattern and describe what they observe when the paper is removed.

Ask the students why they think they obtained these results. Ask them what colors they think would be good to wear in the summer and in the winter.

# 5. Have students demonstrate how latitude and the earth's curvature affect temperature. Compare the light from a flashlight held at right angles to a wall. Shine a flashlight on a wall. Hold the flashlight at various angles. Ask children to infer which angle provides the greatest amount of energy received by various parts of the earth.

Have students place pans of soil at various angles to the sun, measure the temperature of each sample, and compare temperature differences, if any.

Discuss the effect of geographical location and temperature on the lives and work of people.

Instructional Objective

Given appropriate materials and instructions, construct and calibrate instruments used to measure weather conditions.

Concepts

Thermometer
Barometer
Anemometer
Wind vane
Hygrometer
Rain gauge

Learning activity:

# Let students use reference materials to find instructions for making weather instruments. Use the pictures and instructions given below as needed. Have students collect as much of the materials as they can. Students may work individually or in groups. Some students may wish to construct an instrument at home and bring it to school. Use good judgement when determining how many of these instruments you wish students to make and bring into the classroom.

Instruction for Constructing Weather Instruments

Thermometer

Materials needed:

bottle
one-hole stopper

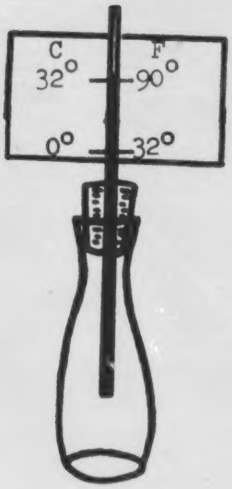
Materials needed: (continued)

- 40-50 cm glass tubing
- colored water
- paper and pencil

Learning activity:

Fill a "pop" bottle with colored water. Place the tube in the stopper. (Wet tube and stopper. Hold tubing close to the end nearest the stopper and twist gently. Children can get cut easily. The teacher may wish to insert the tubes.)

Push the stopper firmly into the bottle so the water rises high in the tube. Place a paper strip on to the tube as shown below. Calibrate thermometer by placing it in an ice bath and warm water, then compare it with a commercially made thermometer.



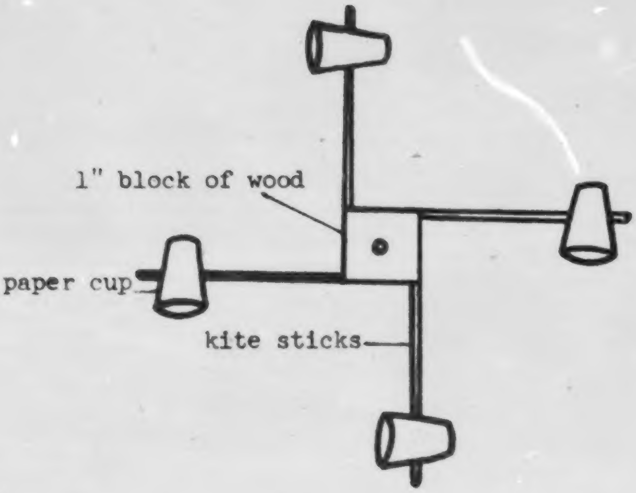
Anemometer

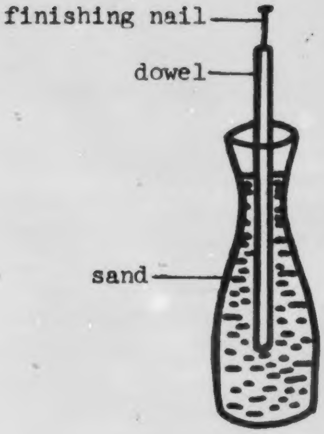
Materials needed:

- 4 paper cups (3-6 oz.)
- kites sticks or applicator sticks (fondue)
- 12" dowel rod 1/2" diameter
- glass tubing
- pop bottle
- sand
- coat hanger wire

Learning activity:

An anemometer consists of four cups mounted on sticks fastened at right angles. This is mounted on a support in such a way that it rotates freely.



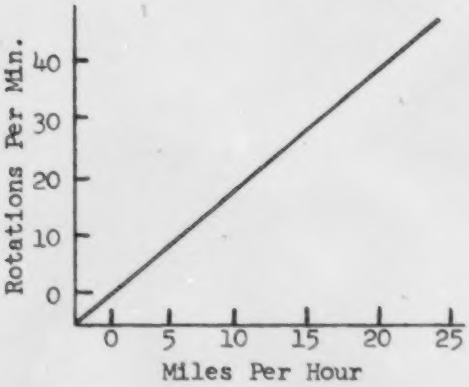


Drill a hole, part way, into the end of a block of wood, 1" x 1" x 2". Drill a hole into the dowel rod. Insert the nail into the hole. Hang the rotating system on the nail so it rotates. Place the dowel rod into a bottle containing sand.

A piece of coat hanger wire inserted directly into the sand will also work.

Calibrate the anemometer by holding it out a car window and counting the number of rotations in 15 seconds as the driver keeps the car at a steady pace of 5 m.p.h., then 10 m.p.h., and so on.

Make a line graph like the one below to help convert rotations to miles per hour. If the rotations are counted for three or four speeds, say, 5, 10, 15, 20 m.p.h., the other speeds in between can be interpolated and speeds beyond 20 m.p.h. can be extrapolated.



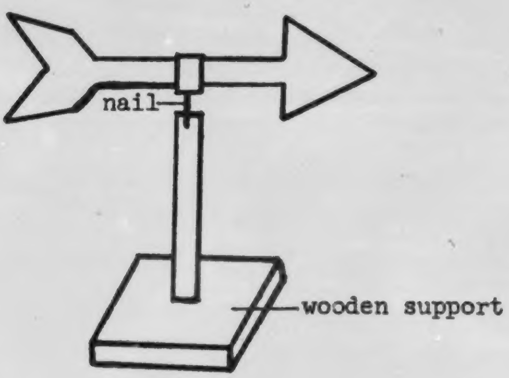
Wind Vane

Materials needed:

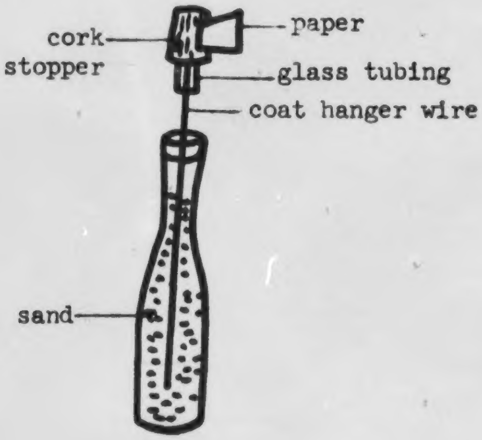
- cardboard
- wooden support
- saw
- cork stopper
- bottle
- paper
- glass tubing
- drill
- wooden block, 1" x 1" x 2"
- cork borer
- coat hanger wire
- sand

Learning activity:

Glue a cardboard arrow onto a piece of wood with a hole in the bottom. Place it on a nail or piece of coat hanger wire at the place where the arrow balances.


nail
wooden support

Another types can be made by sliding a piece of heavy paper into a slot made in one side of a cork stopper. Place a piece of glass tubing, closed on one end, into the large end of the stopper. Place it on a piece of coat hanger wire or nail. The piece of paper should be in the shape of a trapezoid with the small side in the stopper.


paper
cork stopper
glass tubing
coat hanger wire
sand

Hygrometer

Materials needed:

- two thermometers
- milk carton
- shoe string
- relative humidity chart

Learning activity:

Attach two thermometers to one side of a milk carton about 6 cm from the bottom. Cut a piece of shoelace, about 8 cm long, and slip it on the bulb of one thermometer. Cut a 1 cm horizontal slit about 1 cm under the thermometer. Insert the loose end of the shoelace through the slit. Pour water into the carton to a depth of about 4 cm.

When reading the thermometers, fan the wet bulb until the temperature will go no lower. Read both thermometers. Use the dry bulb reading and the difference between the wet bulb and dry bulb reading to find the relative humidity on the chart. The children may wish to put a relative humidity chart on the milk carton or some other convenient place.

Rain Gauge

Materials needed:

- olive jar or large test tube
- funnel or cone shaped paper cup
- glass jar, same diameter as funnel or cup
- 3"x 5" card

Learning activity:

Pour water into the jar until it is one cm deep (or one inch deep). Pour the water into the olive jar. Make a mark on the card to indicate the level of the water. Label this mark one cm (or one inch, as the case may be). Make marks of equal distance on the card to show 2 cm, 3 cm, or 4 cm (or up to two inches). Tape the card to the olive jar. Place the funnel into the olive jar and set outside. It may be necessary to anchor the olive jar by placing it in another jar or by placing it in sand. If a cone shapped paper cup is used, it must be taped securely to the jar or the wind will blow it away.

Barometer

Materials needed for tin can barometer:

- empty condensed milk can
- sealing wax
- glue
- large cork stopper
- kite stick
- straight pin
- 3" x 5" card
- 1/2 gallon milk carton

Materials needed for balloon barometer:

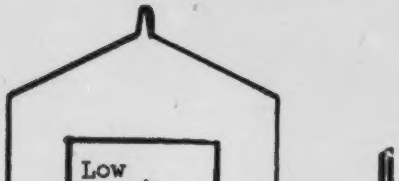
- juice can
- round balloon
- twine
- 1/2 gallon milk carton
- cellulose tape
- drinking straw
- 3" x 5" card
- scissors

Learning activities:

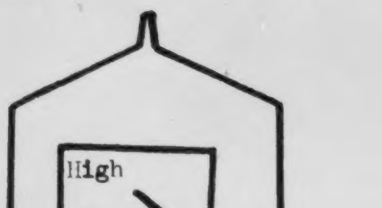
1. A tin can barometer. Clean an empty condensed milk can, heat it in hot water and plug the holes with sealing wax. Fasten a large cork stopper to the center of the can with glue. Fasten a piece of kite stick about 15 cm long to the side of the tin can with twine. Fasten one end of the drinking straw to the kite stick with a straight pin or a thumbtack so that the straw rests on the cork stopper. Draw a scale from high to low on a 3" x 5" card. Glue the card to one side of a milk carton and place it so that the straw points to markings on the card to indicate the air pressure.

2. A balloon type barometer. Heat an empty juice can in hot water. Cut off the open end of a round balloon and slip it over the top of the can. Stretch it so that the top is flat. Tie the balloon to the can tightly with twine. Fasten a drinking straw to the center of the balloon with glue or cellulose tape. Draw a scale from high to low on a 3" x 5" card. Fasten it to the milk carton so the straw can point to the scale to indicate air pressure.

   Use a commercial barometer or information from newspaper and TV to help calibrate the barometer.



Tin Can Barometer



Balloon Barometer

Instructional Objective

Given the Beaufort Wind Scale and appropriate objects outdoors, estimate the speed of wind.

Concepts

Wind
Beaufort Wind Scale

Materials needed:

Beaufort Wind Scale
a view of a smokestack, a flag, and trees
reference materials

Learning activities:

# 1. Let students practice using the Beaufort Wind Scale to estimate the speed of the wind. Make the scale available to the students in a book, a ditto sheet, or on the bulletin board. Compare estimates with the radio or newspaper weather reports and with information from anemometers. Discuss how approximations based on a chart may sometimes be used instead of precise measurement with instruments. Who might use a chart instead of a wind gauge?

# 2. Let students use reference books to find information about Admiral Beaufort, the man who invented the Beaufort Wind Scale. Ask, "Who was he? What was his work? Why did he develop the wind scale?"

BEAUFORT WIND SCALE

Beaufort Scale Number	Wind Description	Miles Per Hour	Observation
0	calm	0 - 1	smoke rises straight up
1	light air	1 - 3	smoke drifts slightly
2	slight breeze	4 - 7	flags flap, leaves rustle
3	gentle breeze	8 - 12	flags blow straight out, leaves and twigs move
4	moderate breeze	13 - 18	dust blows, branches move
5	fresh breeze	19 - 24	small trees bend
6	strong breeze	25 - 31	large branches move
7	high wind	32 - 38	large trees bend, difficult to walk
8	gale	39 - 46	branches break off trees
9	strong gale	47 - 54	buildings damaged
10	whole gale	55 - 63	trees uprooted
11	whole gale	64 - 72	widespread damage
12 or more	hurricane	73 -	disastrous damage

Instructional Objective	Concepts
Given a specific weather instrument, read it correctly.	Thermometer Barometer Hygrometer Rain Gauge Wind Vane Anemometer

Materials needed:

- thermometers
- barometers (commercial or homemade)
- wind vane (homemade)
- anemometer (homemade)
- hygrometer

Optional materials:

- ditto sheets
- transparencies
- filmstrips or other media

Learning activities:

# 1. Pass out thermometers. Have children read the present temperature. Use a drawing on the board or a picture of a thermometer to help demonstrate how to read a thermometer. Children often have difficulty with parallax. Instruct them to hold the thermometer at eye level. Most thermometers are calibrated in intervals of 2°. Have students read the thermometer in both Farenheit and Celsius scales to the nearest 2°.

2. Reading an aneroid barometer requires some knowledge of fractions and decimal notation. The air pressure is usually given in hundredths of an inch of mercury. Use the variable manual indicator to give practice reading the barometer. A picture or transparency would be helpful.

3. A wet and dry bulb hygrometer requires two thermometer readings and the use of a conversion table. The relative humidity is given as a percent. Provide hypothetical wet and dry bulb readings for students to use in learning to use the conversion table before making actual readings.

4. When reading a rain gauge it is necessary to line up the correct marking with the bottom most part of the water surface (the bottom of the miniscus). Rain gauges measure water in inches so children need to be able to read the scale in tenths and hundredths of an inch.

5. Wind vanes point into the wind. The directions can be determined by a compass. Most wind vanes have direction indicators and need to be oriented properly.

Relative Humidity Conversion Table

Dry-Bulb Reading	Difference Between Dry-Bulb and Wet-Bulb Readings (In Degrees Fahrenheit)																	
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°
54°	94	88	80	74	69	67	61	55	49	45	39	36	28	24	18	15	11	7
56°	94	89	81	75	70	68	62	56	51	46	41	33	30	26	20	16	13	9
58°	94	89	82	76	71	68	62	57	52	48	42	36	32	28	23	18	15	11
60°	95	90	83	77	72	69	63	58	54	49	44	39	34	30	25	21	18	14
62°	95	90	84	78	73	70	64	59	54	50	45	41	36	32	28	24	20	16
64°	95	90	84	79	74	70	65	60	56	51	47	43	38	34	30	26	22	18
66°	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	29	25	21
68°	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	31	27	23
70°	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	29	25
72°	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	34	31	28
74°	95	91	86	82	78	74	69	65	61	58	54	50	47	43	39	36	33	29
76°	96	91	87	82	78	74	70	66	62	59	55	51	48	44	41	38	34	31
78°	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	36	33
80°	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	38	35
82°	96	92	88	84	80	76	72	69	65	61	58	55	51	48	45	42	39	36
84°	96	92	88	84	80	76	73	69	66	62	59	56	52	49	46	43	40	37
86°	96	92	88	84	81	77	73	70	66	63	60	57	53	50	47	44	42	39
88°	96	92	88	85	81	77	74	70	67	64	61	57	54	51	48	46	43	40
90°	96	92	89	85	81	78	74	71	68	65	61	58	55	52	49	47	44	41
92°	96	92	89	85	82	78	75	72	68	65	62	59	56	53	50	48	45	42
94°	96	93	89	85	82	79	75	72	69	66	63	60	57	54	51	49	46	43
96°	96	93	89	86	82	79	76	73	69	66	63	61	58	55	52	50	47	44

Instructional Objective

Given appropriate weather instruments, measure and record weather information on a chart and/or graph.

Concepts

Weather instruments
Weather elements

Materials needed:

- thermometers
- aneroid barometer
- wind vane
- anemometer
- hygrometer, with humidity conversion table
- graph paper
- chart paper

Learning activities:

# 1. Have children take readings of temperature, air pressure, humidity, wind speed, and direction the same time each day for several weeks. Also include cloud types and the amount of cloud cover (clear, cloudy, partly cloudy). Information may, also, be obtained from newspapers, television, or calls to the Weather Bureau. (Limit calls to one per day, per school.) Have them record these on a chart similar to the bulletin board. Also, keep a written description of the weather for each day. Have students role play the TV weather man giving a report using the data collected in class.

	Date and Time	Date and Time	Date and Time
Temperature			
Air Pressure			
Relative Humidity			
Clouds			
Wind Speed			
Wind Direction			
Precipitation			

2. Some of the information above may also be recorded on graphs. High and low daily temperatures may be recorded on the same graph using two different colors. The teacher may, also, wish to have a graph of the air pressure. This information can be used to make generalizations about the weather over a period of time.

Instructional Objective

Concept

Given recorded information, compare the data with descriptions of weather over the same period of time.

Weather elements

Materials needed:

newspaper weather reports
recorded weather data

Learning activity:

Ask the children to compare descriptions of the weather for a particular day with the air pressure and temperature. Ask, "What kind of weather did we have when the air pressure was rising?--falling?" Ask the students to compare temperature and pressure and make any generalizations they can about the comparison. Also, compare air pressure with cloudiness. Encourage the students to make other comparisons. Let them test hypotheses by keeping records over a longer period of time and finding evidence that supports or does not support the hypotheses. (They should learn that cold days have reltatively higher pressure and clear skies, and falling barometer readings are indications of approaching cloudiness and usually precipitation.)

Instructional Objective	Concept
Given pictures of clouds, identify each major cloud type by name.	Clouds

Materials needed:

pictures of clouds
reference books

Learning activities:

1. Have students use pictures to learn the names of cirrus, cumulus, and stratus clouds. Have them compare the pictures to real clouds to help identify them.

2. Over a period of time, record the kinds of clouds seen and the amount of the sky covered (in tenths). Also, record the type of weather observed and the wind direction.

	Date	Date	Date
Cloud Type			
Sky Cover (in tenths)			
Wind Direction			
Type of Weather			

# 3. Have students look up information concerning the various cloud types and find out what type of weather accompanies or follows each type. Identify people and occupations in which some knowledge of cloud types and the weather phenomena that accompany them is valuable.

Instructional Objective	Concept
Given samples of water evaporating, identify the variables that affect evaporation.	Evaporation

Materials needed:

water
containers of many sizes and shapes
chalk board
assortment of absorbent and non-absorbent materials
hot plate

Learning activities:

1. Provide students with a variety of materials, both absorbent and non-absorbent. Let them fill various containers with water. Make heat sources available to them. Instruct the students to select a material and/or a container and see how long it takes water to evaporate completely from it.

   Let students have races to see who can get spots of water on the chalk board to dry the fastest.

# 2. Have students give everyday examples of evaporation and identify ways in which the rate of evaporation may be increased or decreased. Some ideas they may suggest are:

Increase	Decrease
heating	lids on containers
fanning	oil on reservoirs
spreading out	using narrow necked bottles
opening containers	storing in cool areas
uncovering cookware	
raising to higher elevation	

Instructional Objective	Concepts
Given appropriate materials, determine the relationship between the rate of evaporation, relative humidity, and comfort.	Evaporation Humidity Comfort

Materials needed:

hygrometer
materials for recording data

Learning activities:

1. Help students design an investigation to compare the rate of evaporation with relative humidity.

   Wipe a damp sponge on a 30 cm square of some non-porous material outdoors. Measure the length of time it takes for the surface to get completely dry. Record evaporation time, relative humidity, temperature, and a description of the comfort level over a period of days. Have students look for patterns and discuss relationships indicated on the chart.

	Date and Time	Date and Time	Date and Time
Temperature			
Relative Humidity			
Evaporation Rate			
Comfort Level (describe)			

# 2. Ask students to name appliances that are used to control humidity in the home (humidifier, dehumidifier, air conditioner). Discuss how people's comfort affect their capacity for work.

Instructional Objective	Concepts
Given appropriate materials, demonstrate condensation.	Condensation Dew Frost Dew Point Cloud Fog

Materials needed:
- ice
- salt
- water
- metal and glass containers
- soil
- reference books

Learning activities:

1. Let students experiment with cans containing ice, water, and salt. Ask them to watch and feel the outside of the container. When water begins to appear on the can; ask, "How did the water on the can appear?" Have students describe what they see and feel. Continue until ice forms. Ask, "What do we call this when it forms outdoors? Where does water and ice like this usually collect?" Introduce and define the words "dew," "frost," and "condensation."

2. Have students place jars containing damp soil or damp paper towels on a warm radiator with the lid off for 15-20 minutes. Tell them to take them off the radiator, put the lids on, and observe over a 10-15 minute period. Then leaving the lids on, place the jars back on the radiator and observe. Discuss what happened. Have the students compare their observations when the jar was on the radiator to their observations when it was off.

   Ask, "What differences did you notice? What happened when the jar was on the table? What happened when you put it back on the radiator? What happened to the water? Where did it go? Why did it appear when the jar was placed on the table?" Then ask, "Which holds more vapor, warm air or cold air? What is your evidence?"

3. Let students use the following directions to find the dew point of the air.

   Fill a can 1/3 full of water that is near room temperature. Place a thermometer in the water and watch it constantly. Lower the temperature by adding ice. Record the temperature at which moisture first appears on the outside of the can. This is the dew point.

Have students record the dew point over a period of days. If they also record the temperature, humidity, and the air pressure, they should be able to find patterns and identify variables which affect dew point. The following data sheet may be helpful.

Date	Dew Point	Temperature	Humidity	Air Pressure

4. Cloud and fog formation can be demonstrated as follows:

   Place hot water into a bottle to a height of about 4 cm. Place an ice cube at the mouth of a bottle. Look into the bottle toward a light. Describe what you see. Of what is it made? The introduction of a little smoke into the bottle will help the condensation form and will make it more clearly visible.

   Let students use reference books to find additional information on the formation of clouds and fog.

# 5. Have students look for examples of condensation at school, at home, and in the community. Ask students how condensation can cause damage, and ways condensation can be controlled. Some examples that students may suggest are: water forming on cold drink containers; frost in the refrigerator; condensation on bathroom mirrors, tile, and walls; and dampness in basement.

Instructional Objective	Concepts
Given forms of precipitation, identify them by type and describe the formation of each type.	Precipitation Rain Snow Sleet Hail

Materials needed:

access to the outdoors
pictures of precipitation forms
reference materials

Learning activity:

Take advantage of days when there is precipitation. Have students describe what is happening. Let them look up the names of each type and report or draw a diagram explaining how each type is formed.

Develop the concept of "precipitation." Define the term and encourage students to use it.

Instructional Objective

Given a sample of water boiling, distinguish the liquid from the gas.

Concepts

Evaporation
Condensation
Water vapor
Steam
Water cycle

Materials needed:

water
hot plate
glass beaker
reference sources

Learning activities:

1. Use a hot plate to boil water in a glass beaker. Have students describe their observations. Ask the following questions to stimulate discussion. "What do you see? What is causing the bubbles? What is inside the bubbles? Why do they rise? What is the "white stuff" rising from the water? How can we collect some of it? What part of this system is liquid? What part is a gas?"

2. Let the students use reference sources to check their ideas. Have them find the definitions for some of the terms they used, such as water vapor, steam, gas, liquid, boil, evaporate, and condense. Repeat the activity above and have the students explain their observations. Have the students review the parts of the boiling water system that are gaseous and liquid. Be sure they distinguish the difference between condensed water and steam or vapor. Introduce and define "water cycle."

3. Place cold objects above the boiling water and have the students describe what happens. Make "rain" by holding a pan filled with ice cubes over the boiling water.

Instructional Objective

Given appropriate materials, illustrate the water cycle and trace the movement of water throughout the water cycle.

Concepts

Water cycle
Evaporation
Condensation
Precipitation

Materials needed:

paper
pencils
reference materials
water cycle transparency

Learning activities:

1. Have children describe what happens to water on the earth as the earth is warmed by the sun. Have them draw pictures showing water as it evaporates into the air. Ask them to draw arrows showing the direction the water moves. Have them put some form of condensation and precipitation in their picture. Use the term "water cycle" to develop the concept of the cyclical phenomena that occurs constantly in the atmosphere.

2. Use the children's pictures and a transparency of the water cycle to have the children trace the movement of water through the water cycle. Encourage them to state the many different places water might be found in the earth, the many forms of condensation and precipitation can take as water moves through the water cycle.

3. Have students identify ways that people modify and use the natural water cycle. Some examples are: cloud seeding, storage of water in reservoirs and man-made lakes, atomic energy plants, irrigation, farming, and the like. Ask, "How are these helpful to man and his environment? How are they harmful? What kind of careers have emerged in the struggle to help man use water wisely?" #

4. Discuss with students ways they waste water every day. Have them suggest how they could stop wasting water. Have them examine periodicals for suggestions for conserving water. Some students could make posters urging the conservation of water. #

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

208	Origins of Weather
2052	Our Weather
951	Pressure and Humidity

Sound Films (Continued)

952	Temperature and Wind
93	Understanding Storms
622	Winds and Their Causes

Filmstrips

6393	Clouds, Rain and Snow
623	Lightning and Thunder
6394	Weather
6199	Weather and Seasons
6948	Why Does the Weather Change?
6949	Why Does the Wind Blow?

Recordings

9407	Weather and Climate (Innovation Records)

A-V Media Approved for Purchase

Filmstrips

Aims Instructional Media

Introducing Weather

- Temperature
- Wind
- Moisture
- Air Pressure

Weather and Climate (3 Filmstrips/Guide)

- Sun, Wind and Rain
- Wind Systems
- Climate

Eye Gate House, Incorporated

Meteorology (4 Filmstrips/2 Cassettes)

- The Challenge of Weather
- The Atmosphere
- Heat, Pressure and Winds
- Moisture

Society for Visual Education, Inc.

New Basic Weather Series

- Why Does the Wind Blow?
- Why the Seasons?
- Why Does the Weather Change?
- Why Does It Rain, Snow, Hail, and Sleet?

Filmstrips (Continued)

Society for Visual Education, Inc.

Space and Earth Science

Understanding Weather and Climate (6 Filmstrips/3 Recordings)
Basic Weather Series (4 Captioned Filmstrips)
Familiar Clouds (8 Study Prints)
Climate and Clouds (8 Study Prints)
Weather and Climate (2 Recordings)
Meteorology (9 Transparencies)

Understanding Weather and Climate

How to Forecast the Weather
Weather Changes and Their Cause
Moisture and Precipitation in the Air

Transparencies

Hubbard Scientific or Harold D. Furst

M-4	Cloud Types I
M-8	Climate
M-0	Temperature

Milliken Publishing Company

Weather Science (20 Transparencies/20 Duplicator Masters)
Meteorology and Climatology (16 Transparencies/16 Dupl. Masters)
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A. J. Nystrom and Company

Meteorology (19 Transparencies)

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Meteorology

Study Prints

Instructional Aids, Inc.

Set 3	Weather Instruments
Set 6	Cloud Formations
Set 18	Weather Phenomena

Society for Visual Education, Inc.

SP-115	Familiar Cloud Forms

FORECASTING THE WEATHER

Background

Understanding how weather is forecast requires a knowledge of winds, air masses, fronts, and weather maps.

Winds. Winds occur when high-pressure, cooler air pushes toward low-pressure, warmer air. Wind is caused by the unequal heating and cooling of the atmosphere. The atmosphere is warmed very little by the sun directly. The earth's surface becomes heated as it absorbs the sun's radiation and in turn heats the air above it. Daylight and night, lattitude, altitude, the amount of radiation absorbed by different surfaces, cloud cover, and the earth's curvature account for the unequal heating and cooling of the earth's atmosphere.

Air expands when it is heated, becoming less dense. The more dense cooler air sinks, pushing warm air upward. The rising warm air cools as it spreads out and as it comes in contact with cooler air. It then contracts, becomes more dense, and moves downward again. The continual warming and cooling causes a cycle of air flow called a convection current. We perceive it as wind.

The earth's rotation deflects the wind to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This is called the Coriolis force. It produces a series of wind belts around the earth. These belts shift to the north and south with the change of the seasons.

Local features and conditions can cause breezes. Two examples are land and sea breezes, and mountain and valley breezes.

Air Masses. An air mass is a huge body of air that may cover a large area of the earth's surface. The temperature and humidity are relatively uniform throughout the air mass. The properties of an air mass are determined by the conditions in the areas over which it is formed.

Air masses are named after the regions from which they come. Air masses can be polar, tropical, maritime (formed over water), and continental (formed over land).

Major air masses and their properties follow:

polar-continental	cold - dry
maritime-polar	cold - moist
tropical-continental	hot - dry
tropical-maritime	hot - humid

Cold air masses have higher pressure than warm air masses. Dry air masses have higher pressure than humid air masses.

A low pressure area is called a cyclone. In the northern hemisphere winds move counter-clockwise as they blow toward the center of a cyclone. The lowest pressure of a cyclone is at its center.

A high pressure area, called an anticyclone, has its highest pressure at the center. In the northern hemisphere winds move clockwise as they blow away from the center of an anticyclone.

Severe lows that occur over tropical waters are called hurricanes. Tornadoes are the smallest, briefest, and most violent of storms. They occur mostly in Central United States. Thunderstorms may be local or frontal. A local thunderstorm occurs on hot summer afternoons when hot moist air rises, forming cumulo-nimbus clouds. A cold front may produce a series of thunderstorms along its edge.

Fronts. Warm and cold air masses do not mix freely when they meet but form a transition zone called a front. Fronts usually produce precipitation.

The four main types of fronts are:

Warm front	A warm air mass is overtaking a cooler air mass. Air pressure drops, humidity rises, rain occurs over an extended period of time.
Cold front	A cold air mass is overtaking a warmer air mass. Air pressure rises, wind speed increases, brief but violent storms occur, humidity drops, skies become clear.
Occluded front	A cold air mass moves under a warm air mass and meets another cold air mass.
Stationary front	A front that is not moving.

Air masses and their accompanying fronts move across the United States from west to east.

Weather Maps. Weather predictions are made by examining the data gathered by weather instruments. Weather data is plotted in special symbols on weather maps. Isobars (lines of equal pressure) and isotherms (lines of equal temperature) are drawn to locate highs, lows, and fronts. The meteorologist studies weather maps at different altitudes and compares them with maps of previous days. Because of his past experience and his understanding of how the atmosphere behaves, he is able to make fairly accurate predictions.

The United States weather bureau gathers information from ground stations all over North America, from ships, from aircraft, and from weather satellites. The World Meteorological Organization coordinates weather information among nations.

Rationale

A study of weather forecasting should enable students (1) to develop concepts of the many variables that affect weather, such as winds, air masses, and fronts, (2) to develop a perception of weather on a global scale,

(3) to understand the weather forecasts in the various news media, and (4) to make weather predictions based upon their own observations. The weather affects many activities of children as well as those of adults. Weather information is critical to many industries, military operations, and recreational activities.

Glossary of Concepts

Convection current	The movement of gases and liquids caused by their unequal heating and cooling.
Wind	Moving air.
Wind belts	Bands of latitude roughly 30° in width which have winds of distinct properties.
Air mass	A large body of air that has much the same properties throughout.
Tropical	Pertaining to the tropics. The part of the earth within 23½° north latitude and 23½° south latitude.
Polar	Pertaining to the poles. The regions within 23½° of the north and south poles.
Continental	Pertaining to large land masses.
Maritime	Pertaining to bodies of water, specifically oceans and seas.
Low	An air mass of comparatively low air pressure--a cyclone.
High	An air mass of comparatively high air pressure--an anticyclone.
Front	A boundary of changing weather between two air masses.
Warm front	The boundary formed when a warm air mass overtakes a cold air mass.
Cold front	The boundary formed when a cold air mass replaces a warm air mass.
Weather map	A map on which weather data is recorded in symbols.
Isobar	Lines of equal air pressure on weather maps.
Isotherm	Lines of equal temperature on weather maps.
Weather forecast	A prediction of weather conditions for a given geographical area over a specified period of time.

Meteorology	The science of weather; the study of weather phenomena and weather forecasting.

Investigations

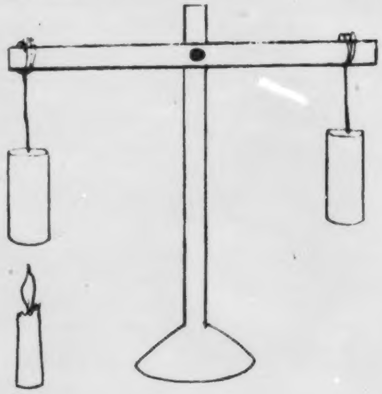
Instructional Objective	Concept
Given appropriate material (1) predict what will happen when samples of air are heated unequally, (2) test the prediction by experiment, and (3) infer why the heated air behaves as it does.	Convection

Materials needed:

- 2 metal cans (same size)
- equal arm balance
- twine
- candle, alcohol burner, or other heat source

Learning activity:

Attach pieces of twine to the bottom of the cans. Hang the cans on the arm of the balance so they balance each other. Place a candle under one can. Predict what will happen when the candle is lighted. Light the candle and observe. Ask, "Is this what you expected? Why? Why not? What happens to a gas when it is heated? What would happen if both cans were heated equally? Why do the cans behave as they do when heated?"



Instructional Objective	Concept
Given appropriate materials, demonstrate and describe the behavior of convection currents in air.	Convection current

Materials needed:

gas convection box with lamp chimneys
candle
a piece of window shade cord

Learning activities:

1. Light the candle and place it under one of the chimneys on the convection box. Light one end of the window shade cord and blow it out. Let students place the smoking cord above each chimney, and describe what happens.

   Ask, "Which direction did the smoke go on the warm side? Which way did it go on the cold side?"

# 2. Have students take the smoking cord to an open window. Let them predict which way the smoke will blow and state why. Let them test their prediction. If possible, try the demonstration with the window open from the bottom, then from the top. Discuss convection currents in relation to heating and ventilating a room or a home.

3. Develop the concept of a convection current. Let the students try to define it. Give them the definition if necessary and relate it to the convection box demonstration.

Instructional Objective	Concept
Given appropriate materials, demonstrate convection currents in liquids.	Convection current

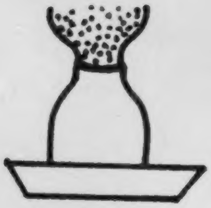
Materials needed:

2 half-gallon milk bottles - clear soft drink bottles
hot and cold water
food coloring
file cards
large plastic tray

Learning Activities:

Fill one bottle with hot water and one bottle with cold water. Place the bottle with the hot water in the large plastic tray. Color the cold water with food coloring. Put the file card across the mouth of the hot water. Carefully invert the bottle, place on top of the cold water and remove the card. Observe. Hold over a plastic tray and quickly invert the hot water. Refill the hot water. Place a fresh file card on top of the cold water bottle. Invert, place atop the hot water bottle, and remove the card carefully. Observe. Use a hand lens. Ask the students to compare the two trials. Which is more dense, hot or cold water? What makes you think so? Did the warm water rise or did the cold water sink and push the warm water up? What do you think? Why?

For obvious reasons, the teacher may wish to do the above as a demonstration. However, by using clear soft drink bottles, it may be possible to let the students do it. As students observe the turbulence between the two bottles ask them if they can see wavy lines. These are "schlieren", made visible because of the difference in the densities of the two fluids.

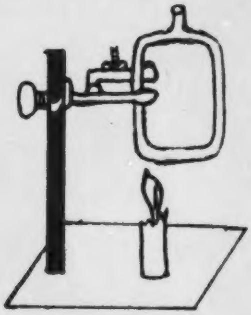


Materials needed:

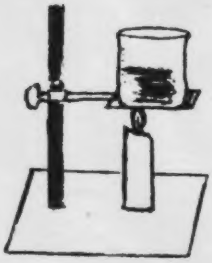
- liquid convection apparatus
- ink or food coloring
- candle, alcohol burner or propane burner
- ring stand with clamp
- water
- ring (3 in or 4 in)
- wire gauge
- beaker

Learning Activity:

Fill the convection apparatus with water. Support it by the clamp on the ring stand as pictured. Heat one side of the apparatus. Place a few drops of ink or food coloring into the water and observe. Have students describe what happens and explain why.



If a liquid convection apparatus is not available, heat one side of a glass beaker filled with water, add the ink or food coloring, and observe.



Instructional Objective	Concept
Given appropriate pictures, draw diagrams of local winds.	Wind

Materials needed:

Dittoed pictures of: a seashore
a plowed field and an adjoining forest
a valley between two mountains
balloon (optional)

Learning Activities:

1. Distribute pictures of a seashore. (If the teacher prefers, the students may draw their own pictures.) Ask the students, "Which would be cooler during the day - the sea or the land? Why? Would the air over the sea have higher or lower pressure than the air over the land? Then which way would the wind blow?" Compare this to the smoke in the convection box and have students devise a diagram showing the movement of air over land and water during the day.

   Using the same procedure above, formulate a diagram that shows the movement of air over land and water at night.

   Does the wind blow from areas of high pressure to areas of low pressure or does it blow from areas of low pressure to areas of high pressure?

   If students have difficulty with this concept, blow up a balloon. Ask students which has higher pressure, the air inside the balloon or the area outside the balloon. Then ask what will happen when the mouth of the balloon is opened. Ask, "Will the air be moving from a high pressure area to a lower pressure area or will it move from a low pressure area to a high pressure area? Release the pressure on the neck of the balloon slowly. Relate this experience to the diagram of the convection current at the seashore.

2. Distribute the pictures of the plowed field and forest, and the mountains and valley. Ask the students to draw pictures of convection currents during the night and during the day for each picture. Discuss the variables of temperature in each situation. Ask, "Which is cooler during the day, the field or the forest? Which is cooler during the night? Why?" Use the same procedure with the mountain/valley picture.

   Ask the students to give other examples of unequal heating and cooling of air that produces convection currents. (The radiator, open refrigerator, and camp fire are other examples.)

Instructional Objective

Given reference material, find and identify global wind belts.

Concept

Wind belts

Materials needed:

reference books and other media
diagram of wind belts

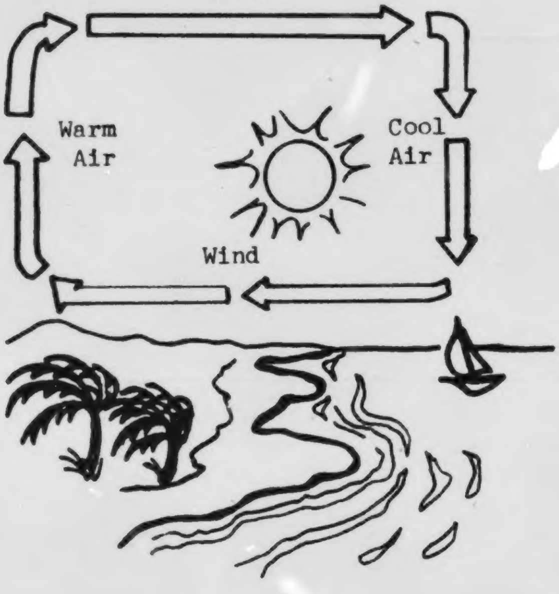
Learning Activity:

Have students use reference material to identify global wind belts. Have them find answers to questions like the following:

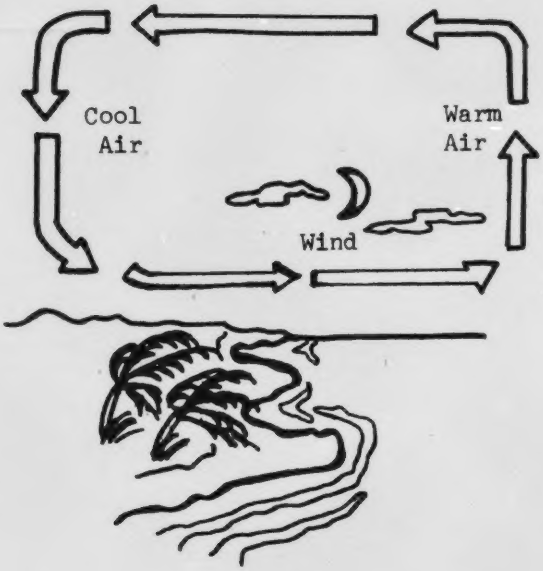
Approximately how many degrees of latitude are included in each wind belt? In which wind belt is the United States? How does the wind belt affect weather throughout the United States?

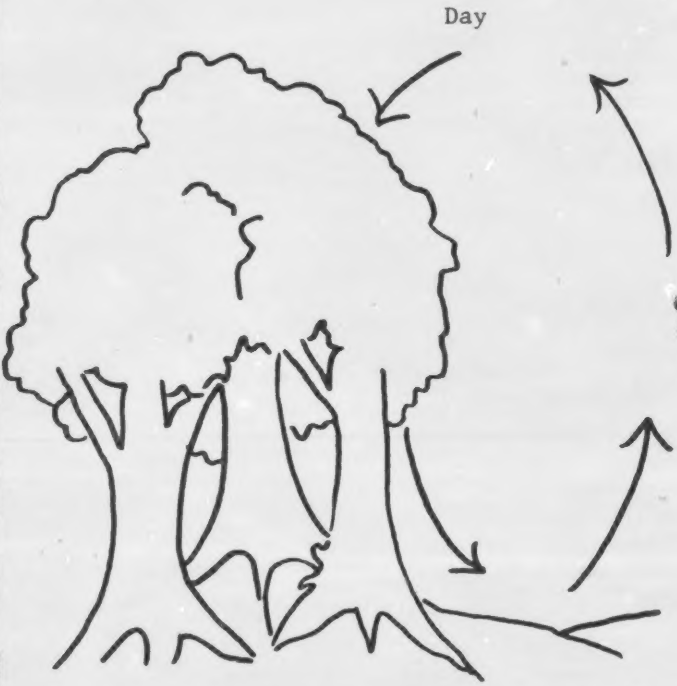
Have the students study the wind belt diagram and ask them to infer why the wind moves in the direction it does in a specific wind belt.

Day



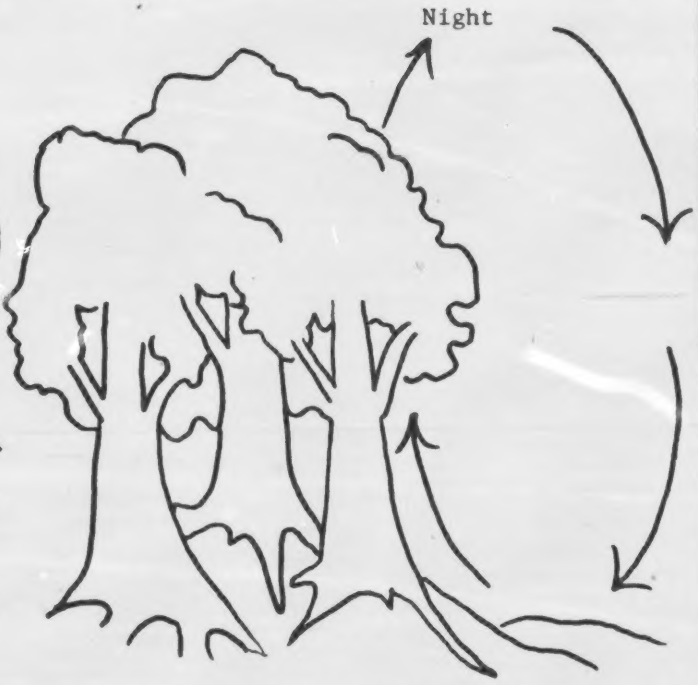
Night





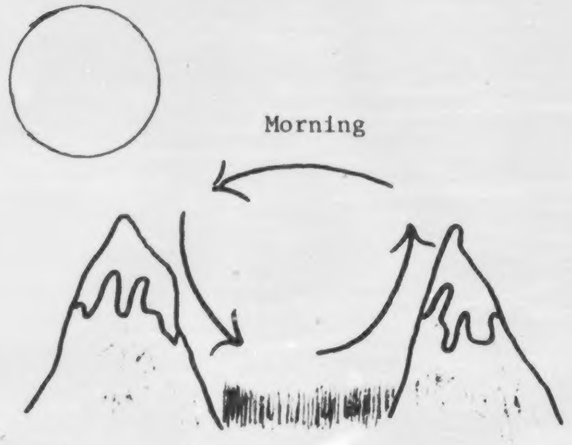
Forest reflects some radiation, making it cooler.

Field absorbs radiation, making it warm.

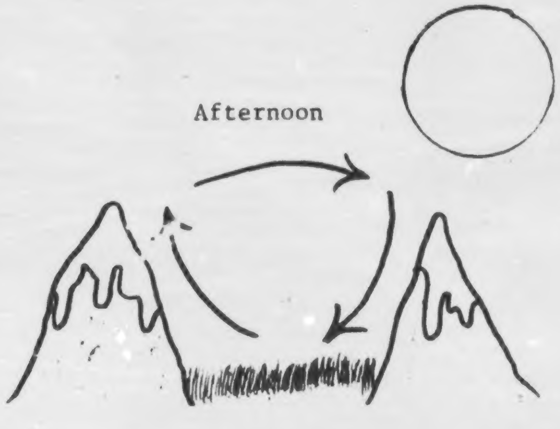


Forest radiates heat slowly, making it warmer at night.

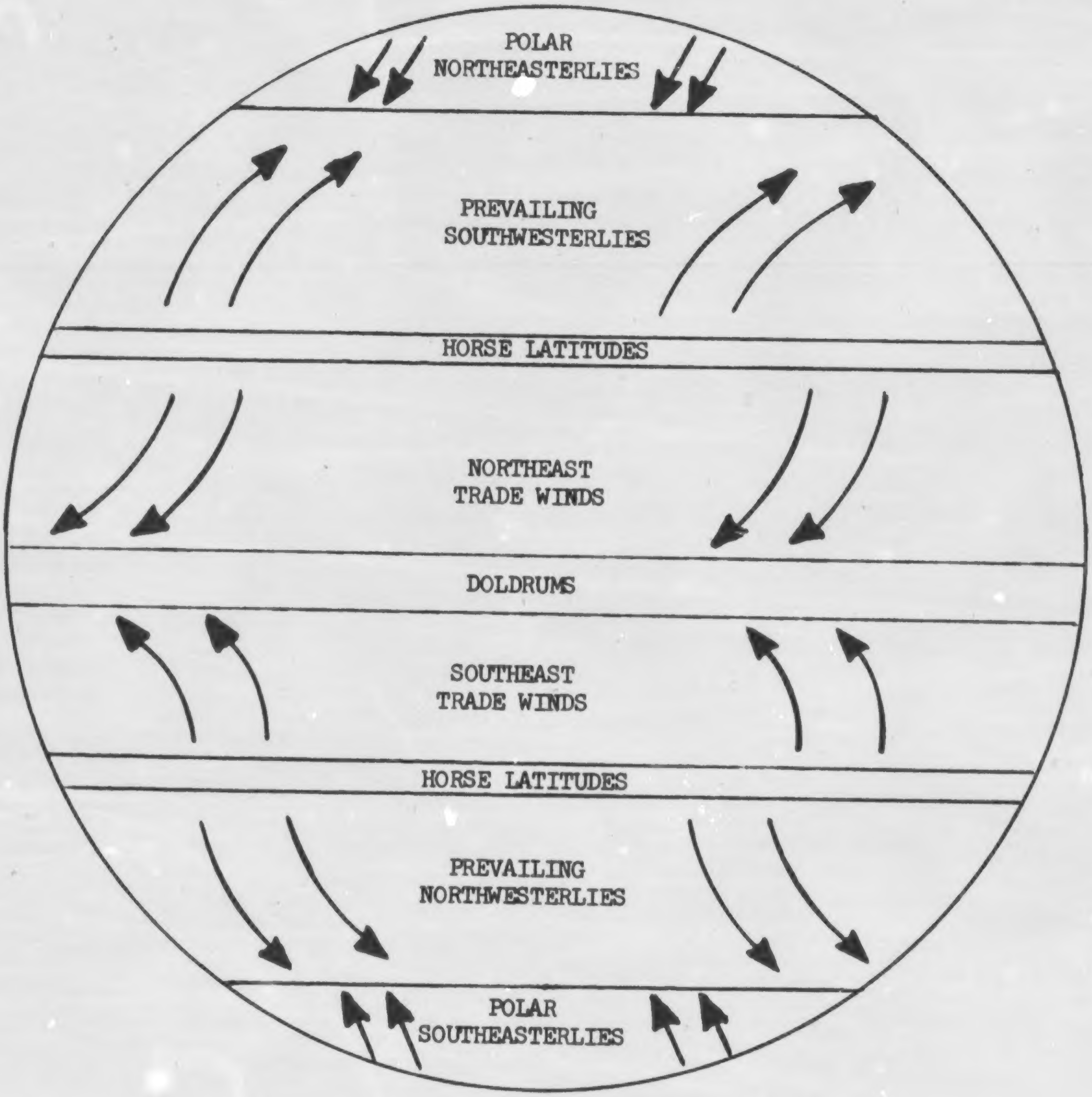
Field radiates heat quickly, making it cool at night.



The eastern side of the mountain receives the sun's rays early in the morning and is heated much of the day.



In late afternoon the valley and western slopes receive the sun's heat and the wind is reversed.


POLAR
NORTHEASTERLIES
PREVAILING
SOUTHWESTERLIES
HORSE LATITUDES
NORTHEAST
TRADE WINDS
DOLDRUMS
SOUTHEAST
TRADE WINDS
HORSE LATITUDES
PREVAILING
NORTHWESTERLIES
POLAR
SOUTHEASTERLIES

Instructional Objective	Concepts
Given a map of North America, name and describe the properties of the air masses that affect it.	Air mass Tropical Polar Continental Maritime

Materials needed:

- map of North America showing unlabeled air masses
- reference materials

Learning activity:

# Have students study the map of North America showing the major air masses (unlabeled). Ask, "Which air masses are over water? over land? Which air masses are warm? Which are cold?"

Introduce the terms continental, maritime, polar, and tropical. Have the students define each. Define the terms for them, if necessary. Then have the students name each air mass on the map as maritime or continental and polar or tropical. Then let the students try to give the properties of each air mass in terms of temperature and moisture. Have them infer what direction the air masses will move and give reasons why. (The relative pressure and the wind belt will help determine the direction the air masses will move.)

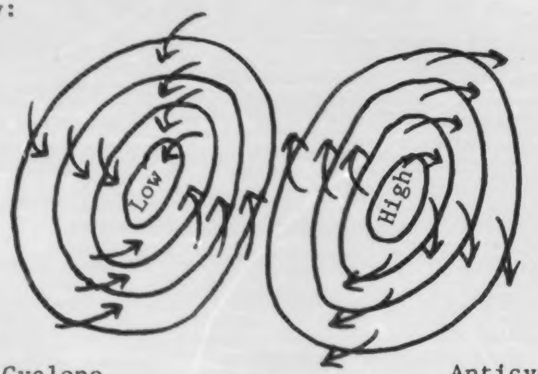
Let the students use reference material to check their conclusions, to reinforce the concepts involved, and to find additional information. Also, discuss how different kinds of air masses influence the life styles, work and recreation of people.

Instructional Objective	Concepts
Given a diagram of a cyclone and anticyclone, infer their properties.	Low High

Materials needed:

- reference material
- cyclone diagram (picture or transparency)
- anticyclone diagram

Learning activity:



Cyclone

Anticyclone

Show students a diagram similar to the one above. Each line (closed curve) is an isobar - a line of equal air pressure.

Ask the students the following questions to help them to make inferences about each air mass.

In the high pressure mass, will the wind be moving toward the center or away from it? Why?

In the low pressure mass, will the wind be moving toward the center or away from it? Why?

In which air mass will the air be rising at the center? Why? In which will it be falling at the center? Why?

In which air mass are the winds moving counterclockwise about the center? In which air mass are the winds moving clockwise about the center?

Which air mass would probably contain more water vapor? Which would be warmer?

Have students read to check their conclusions and to find answers to the following:

How wide are these air masses in the continental United States? How wide is a hurricane in the tropics? Which is more violent, a cyclone in the continental United States or a cyclone (hurricane) formed at sea in the tropics?

Which direction would both air masses move across the United States? Why? (From west to east because of the prevailing westerly winds.)

Instructional Objective	Concepts
Given reference material and a diagram of a warm front, predict and describe the properties of a warm front.	Front Warm front

Materials needed:

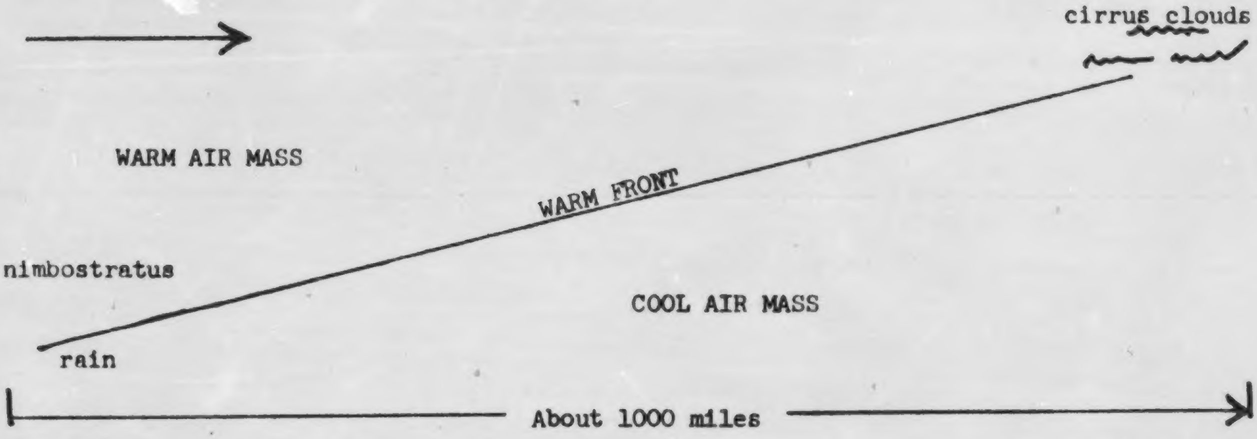
reference books
filmstrips, films, pictures and diagrams
transparency of a warm front

Learning activities:

1. Ask students the following questions. "If a warm air mass moves toward a cold air mass, what will happen? Which is more dense, cold air or warm air? Then what will happen when a warm air mass meets a cold air mass? Will the warm air mass be moving fast or slowly? Why? Which air mass has the most moisture? What will happen to the moisture when the warm air cools?

Introduce the term "warm front". Ask the students if they can define it. Use reference sources to define the term.

2. Use the following diagram to help students explain and understand a warm front. Use a transparency if available.



3. Read books and use other media to find information about the characteristics of a warm front.

The following questions may help guide the reading:

What types of clouds follow a warm front?

When the first clouds appear how long will it take for rain to follow?

Will rain always accompany a warm front? Why? Why not?

What type of rain usually accompanies a warm front?

Instructional Objective	Concept
Given reference material and a diagram of a cold front, (1) predict and describe the properties of a cold front and (2) compare the events of a cold front to those of a warm front.	Cold front

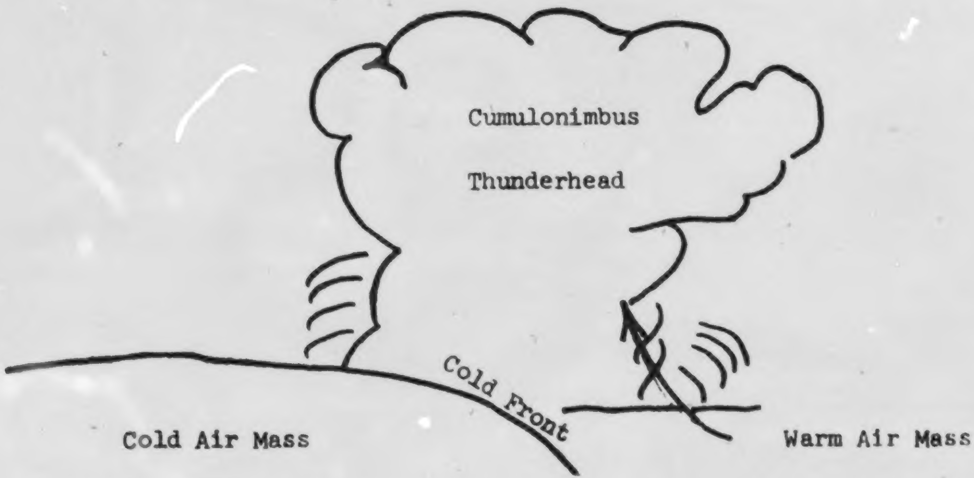
Materials needed:

reference books
filmstrips, films, pictures and diagrams
transparency of a cold front

Learning activities:

1. Ask students the following questions: What will happen to a warm air mass as cold air mass meets it? Which air mass contains more vapor? What will happen to the vapor when the two air masses meet? Will the cold air mass be moving fast or slowly? Why? Will the barometer rise or fall as the cold air mass approaches? What will happen to the temperature? Will the temperature change happen slowly or rapidly? Why? What type of clouds will be formed where the two air masses meet?

2. Introduce the term "cold front" and have the students try to define it. Let them use reference sources to define it. See if the students can develop a diagram (model) to picture what happens during a cold front. Compare what they develop with the following diagram. Use a transparency if available.



3. Read reference sources and other media to reinforce and extend what the students learned in steps one and two. Some students may be interested in reading about thunderheads and make a diagram of the air currents in them.

4. This is a good opportunity to compare and contrast two rather common events. Lead students to develop data sheets to help them compare a warm front with a cold front. The following is a suggested form to use.

	Cold Front	Warm Front
approaching air mass -	cold	warm
retreating air mass -	warm	cold
length of front -	50-100 miles	700-1000 miles
first clouds -	tall cumulus clouds (thunderheads)	cirrus clouds
speed of approach -	rapid	slow
precipitation -	local thunderstorms	steady rain over large area

Instructional Objective

Given weather maps identify symbols used and interpret the meaning.

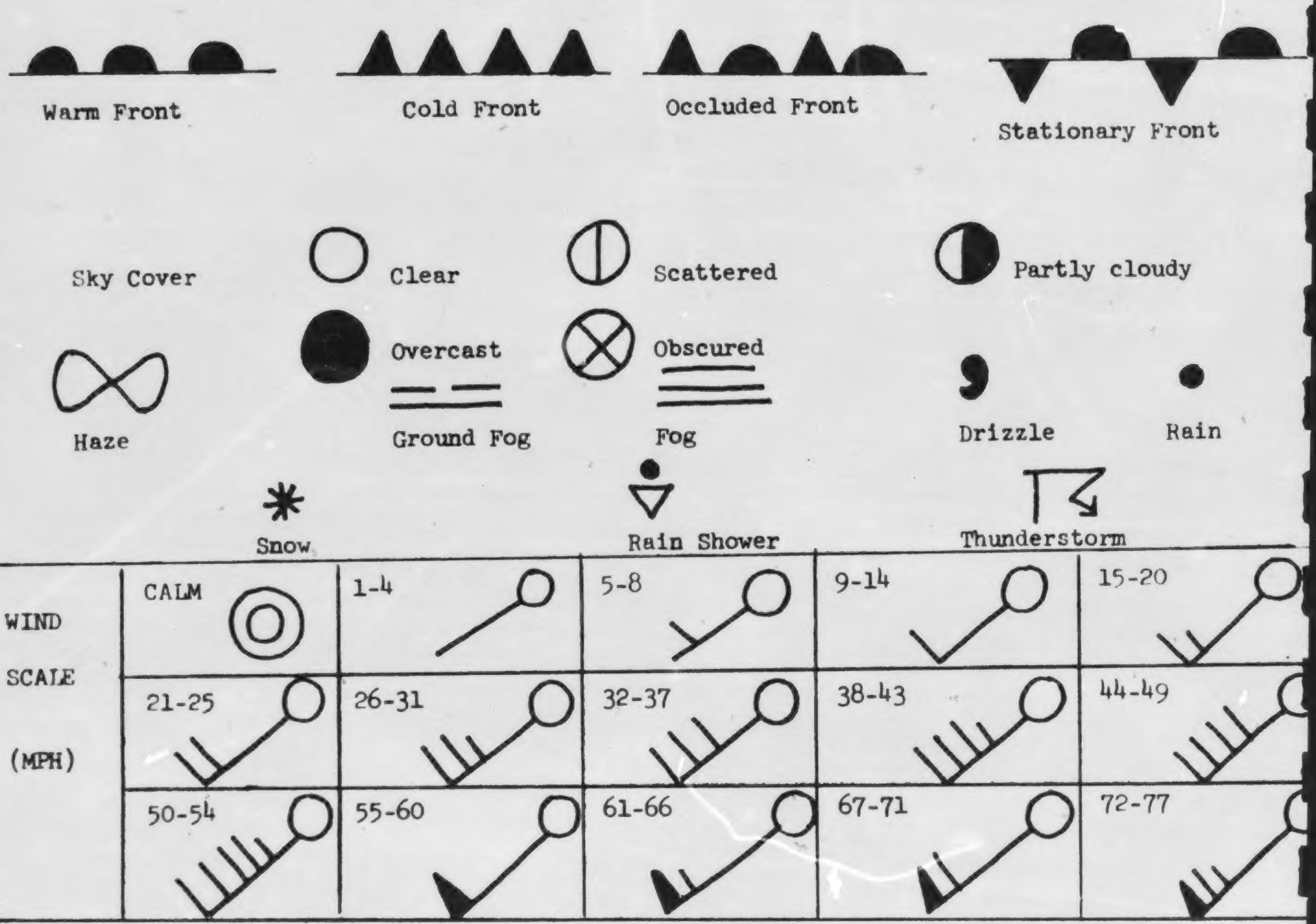
Materials needed:

weather maps from newspapers
official weather map
chart of weather symbols
satellite pictures

Concept

Weather map

Symbols for Weather Maps


Warm Front
Cold Front
Occluded Front
Stationary Front
Sky Cover
Clear
Scattered
Partly cloudy
Overcast
Obscured
Haze
Ground Fog
Fog
Drizzle
Rain
Snow
Rain Shower
Thunderstorm
WIND
SCALE
(MPH)
CALM
1-4
5-8
9-14
15-20
21-25
26-31
32-37
38-43
44-49
50-54
55-60
61-66
67-71
72-77

Learning activities:

1. Have students look at newspaper weather maps and ask them to tell all they can about them. Then show them an official map from the weather bureau. Ask them to report on weather conditions from specific cities. Include wind direction, wind speed, temperature, air pressure, humidity, clouds, precipitation, or any other information. Make the accompanying chart of weather symbols available to them.

   Ask them to locate areas of high and low pressure and fronts.

# 2. Have students look at an official weather map. Have them locate the isobars and isotherms. Direct their attention to the numbers on the isobars and isotherms.

   Ask them how a weather scientist would go about finding the centers of high and low pressure air masses. Ask how the weather scientist would locate a front.

3. Provide a satellite picture of an area and have students compare the picture to the weather map of the same area. Ask the students to explain why the picture looks as it does, supporting their statements with data from the weather map.

Instructional Objective	Concept
Given weather maps, (1) locate highs and lows, (2) trace wind directions around highs and lows, (3) locate and identify fronts and (4) locate areas of precipitation.	Weather map

Materials needed:

weather maps or transparencies of weather maps

Learning activities:

1. Cut out the newspaper weather maps for an entire week. Make transparencies of them. Use these to help children interpret weather maps. If desired, make dittos of the maps so each child can have his own copy to work with.

2. Have students locate the areas of high pressure and low pressure. Have them look for patterns on the maps. Have them trace wind directions on a particular map. Ask them to trace the highs, lows, and fronts for the whole week. Have them locate areas where precipitation is occuring. Use the maps to predict the weather for a given locality.

Instructional Objective | Concept

Given reference materials, find and report information related to the field of meteorology and how it affects people.

Meteorology

Materials needed:

reference books and other media

# Learning Activities:

Have students use reference material to locate information about the following. Let them report what they have learned as the topic comes up in class. Invite a meteorologist to visit the classroom.

1. U. S. Weather Bureau
   - What does it do?
   - Who works at the Weather Bureau?
   - What training do they need?
   - How do you get a job at the Bureau?
   - How much does it cost to run the Weather Bureau?

2. Modern weather tools -
   - radar
   - weather satellites
   - radiosonde
   - weather balloons

3. Storms -
   - cyclones
   - hurricanes
   - tornadoes and typhoons
   - What effect would a storm have on a community - schools, jobs, economics?
   - Who pays for storm damage?
   - How much does it cost to rebuild after a storm?
   - How might these costs affect you even if you aren't in the storm?

5. Man's control of weather -
   - cloud seeding
   - fog control
   - frost control
   - temperature and humidity control inside buildings

5. Meteorology
   - What industries employ meteorologists?
   - What does a meteorologist actually do on the job?
   - How are weather forecasts used by people in various occupations?
   - How do weather forecasts affect recreation activities?
   - What training does a meteorologist need?
   - What skills does a meteorologist need to develop?

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

950	Fronts and Storms
622	Winds and Their Causes (2nd Edition)
623	Lightning and Thunder
208	Origins of Weather
93	Weather: Understanding Storms
1112	The Work of the Atmosphere
2432	Weather Scientists

Filmstrips

6949	Why Does the Wind Blow? (2nd Edition)
6948	Why Does the Weather Change? (2nd Edition)
6393	Clouds, Rain, and Snow
6394	Weather

A-V Media Approved for Purchase

Maps and Charts

George Cram Company

Weather Map (Package of 9)

Models

Central Scientific Company

Areroid Barometer

Filmstrips

Aims Instructional Media

Weather and Climate (3 Filmstrips)

Sun, Wind, and Rain
Wind Systems

Jam Handy

Understanding the Atmosphere (5 Filmstrips)

What is Air Pressure?

Society for Visual Education

Basic Weather Series (4 Filmstrips)

Why Does the Wind Blow?
Why Does the Weather Change?
Why Does It Rain, Snow, Hail, and Sleet?

Sound Filmstrips

- Eye Gate House
  - Earth Science (10 Filmstrips/5 Cassettes)
    - Atmospheric Currents
  - Meteorology (4 Filmstrips/2 Cassettes)
    - The Challenge of Weather
    - The Atmosphere
    - Heat, Pressure, and Winds
    - Moisture
- Society of Visual Education
  - Understanding Weather and Climate (6 Filmstrips/3 Cassettes)
    - Air Masses and Weather Fronts
    - Winds Around the World
    - Humidity and How It Affects Us
    - How to Forecast the Weather
    - Moisture and Precipitation in the Air
    - Weather Changes and Their Causes
- Viewlex Educational Media
  - New Methods of Forecasting Weather (1 Filmstrip/1 Cassette)

Recordings

- Society for Visual Education
  - Weather and Climate (2 Records)

Study Prints

- Instructional Supplements
  - Forces of Nature (6 Study Prints/Set)
    - Weather Phenomena
  - Understanding the Weather (6 Study Prints/Set)
    - Cloud Formation
    - Weather Phenomena
    - Weather Instruments
- Society for Visual Education
  - Basic Science Series (8 Prints/Set)
    - Familiar Cloud Forms

Transparencies

Hubbard Scientific

Meteorology Set I (1 Transparency Per Title)

- Warm and Cold Fronts
- Frontal Movement
- Cloud Types I
- Cloud Types II
- Weather Map
- Coriolis Force

Milliken Publishing Company

Meteorology and Climatology (12 Transparencies/16 Masters)

Weather Science (20 Transparencies/20 Masters)

A. J. Nystrom

Meteorology (19 Transparencies)

Photomotion Corporation

Meteorology (13 Transparencies)

Photomotion Activator

Society for Visual Education

Meteorology (9 Transparencies)

THE SUN, MOON, AND EARTH SYSTEM

Background

The sun, moon, and earth are huge objects separated by great distances. However, their interactions produce many phenomena of great importance to life on the earth. Because of this, these objects may be thought of as a system. The phenomena investigated in this unit are: night and day; up and down; the rising and setting of the sun, moon, and stars; phases of the moon; seasons; eclipses; gravity; and tides.

The Sun. The sun is a huge ball of hot gases. The sun is a star; it is the only star in our solar system. The sun's average distance from the earth is 93 million miles. It is 865,000 miles in diameter and has a surface temperature of approximately 10,000 degrees F (5,500 degrees C).

The sun is the major source of energy for the earth. Its heat and light are essential to the manufacture of food in green plants through the process of photosynthesis. All food on the earth has its origin in green plants. All types of fuels found on and in the earth, such as wood, natural gas, coal and oil, originated in living organisms which obtained energy directly or indirectly from the sun. Therefore, such fuels can be thought of as stored solar energy.

The Moon. The moon is a satellite of the earth. It is a planet-like body that revolves around the earth in an elliptical orbit. The moon revolves around the earth in 27 days, 7 hours, and 43 minutes. Its distance from the earth varies from 221,456 miles to 252,711 miles, with an average distance of 238,857 miles. The diameter of the moon is 2,160 miles. The moon's gravity is approximately one-sixth that of the earth's, therefore an object on the moon would weigh one-sixth as much as it would on the earth. The moon has no atmosphere.

The Earth. Although the earth is a ball shaped object, it is not perfectly round. Its diameter at the equator is 7,926 miles but its diameter at the poles is only 7,900 miles. The earth is one of nine planets that revolve about the sun. It revolves around the sun once a year which is 365 1/4 days. As it revolves it also rotates on its axis. The earth's axis is tilted 23 1/2 degrees in relation to the plane in which it revolves.

Night and Day. A day is the period of time from noon to noon. This is exactly twenty-four hours. Noon is the precise moment the center of the sun crosses the earth's meridian (due south).

The earth revolves around the sun as it rotates so that it must make a little more than one complete rotation each day. A complete rotation takes 23 hours, 56 minutes, and 4.09 seconds.

We also use the word day to mean daylight. This is the period from sunrise to sunset. It is the time in which the part of the earth we are on is lighted by the sun. As the earth rotates, each day, there is a period of daylight and a period of darkness that we call night.

Up and Down. Up and down are deceptively simple concepts. Up is a direction away from the center of the earth and down is a direction toward the center of the earth. When students use a ball or a globe to represent the earth, they must change their frame of reference. Down is toward the center of the globe. Up is away from the center of the globe. Students will tend to think that a person standing at the south pole is hanging downward. The model may confuse the students, at first, but it can be used effectively to help them understand how the concepts of up and down are applied to a spherical body.

Rising and Setting. The earth rotates from west to east. This makes the sun, moon, and stars appear to rise above the eastern horizon, move across the sky and set beneath the western horizon each day. The earth's curvature, the tilt of its axis and its revolution around the sun cause the sun to appear to rise and set earlier or later each day depending upon the season. The moon revolves around the earth from west to east. This causes the moon to appear to rise and set about fifty-one minutes later each day. The revolution of the earth causes the stars to appear to rise and set almost 4 minutes later each day.

Seasons. The changing seasons are caused by the changing inclination of the earth in relation to the sun. The north pole of the earth points almost exactly to the north star, Polaris. As the earth revolves around the sun, the earth's axis is inclined toward the sun in summer and away from the sun in winter. This causes specific places on earth to receive different amounts of sunlight at different times of the year. The sun is higher in the sky during the summer and lower in the sky during the winter. In summer, the days are much longer than the nights, while in winter the nights are longer than the days.

Eclipses. An eclipse occurs when the shadow of one object falls on another object. A solar eclipse occurs when the moon's shadow falls on the earth. The sun's light is dimmed by the moon's shadow and the earth.

A solar eclipse can occur only during a new moon. The moon casts a shadow of no more than 167 miles in diameter, hence a total eclipse of the sun can be seen from only a small part of the earth's surface.

A lunar eclipse occurs when the earth's shadow falls on the moon. A lunar eclipse can occur only during a full moon and then, only when the sun, moon, and earth lie in the same plane. The plane of the moon's orbit around the earth varies 6° from the plane of the earth's orbit around the sun. Therefore, the moon usually passes above or below the earth's shadow.

Tides. Tides are the periodic rising and falling of the oceans. Tides are caused by the gravitational attraction of the moon and sun. High tides occur on opposite sides of the earth, twice daily. The moon attracts the water directly beneath it. On the opposite side of the earth the tides occur because the moon attracts the solid part of the earth away from the oceans.

The sun does not affect the tides as much as does the moon. During the full moon and the new moon the gravitational forces of the sun and moon, being in straight line with the earth, combine to produce especially high tides, called spring tides. When the moon and sun are at right angles to the earth, neap tides occur. These tides are lower than the average tides.

The Effects of Gravity. Gravity is the force which accounts for many phenomena that we experience such as the weight of objects, falling objects, objects slowing down as they move upward from the earth, and objects accelerating as they fall toward the earth.

Gravity is the force of attraction between the earth and other objects. Gravitation is the mutual attraction that all bodies have for one another. Gravitation accounts for one object being held in orbit as it revolves about another object.

Newton's law of gravitation states that all objects attract all other objects, that the force is directly proportional to the object's mass and inversely proportional to the square of the distance between them. This means that the greater the mass the greater its gravitational attraction; the greater the distance between objects the smaller their gravitational attraction for each other. An object weighing 1 kilogram at the earth's surface would weigh 1/4 kilogram 4,000 miles in space and 1/9 kilogram 8,000 miles in space.

Rationale

The unit The Sun, Moon, and Earth System is designed to help students (1) describe and compare the properties of the sun, the moon, and the earth, and (2) develop an understanding of phenomena caused by the movements and interactions of the sun, the moon, and the earth.

The vastness of space and the enormous size of the sun, the moon, and the earth are beyond any experience children have had. A study of the sun, moon, and earth should greatly expand a child's perception of himself and his relationship to the universe. Children have experienced many phenomena caused by the interaction of the sun, moon, and earth, and they are curious about them.

Glossary of Concepts

Sun	The star around which the earth revolves: a ball of hot gases.
Moon	The planet-like satellite that revolves around the earth.
Earth	The planet on which we live.
Planet	One of nine major bodies that revolve around the sun.

Model	An object or a system of objects or pictures used to illustrate actual objects and events. Also, a theory that explains observed phenomena in a given system.
Relative Motion	Motion of an object as it appears to the viewer as though the viewer were still. Motion of one object in relation to another object.
Real Motion	Motion of an object as it actually is.
Daylight	The period from sunrise to sunset.
Night	The period of darkness from sunset to sunrise.
Rotate	To spin in place like a top. The earth rotates on its axis.
Revolve	To move around another object. The earth revolves around the sun.
Axis	An imaginary line around which an object rotates.
Poles	The northernmost and southernmost parts of the earth.
Meridian	Any plane which passes through the earth and intersects both the north and south pole.
Orbit	The path that one object takes as it revolves around another object.
Up	The direction away from the center of the earth.
Down	The direction toward the center of the earth.
Frame of Reference	An object used as a reference for relating the position and motion of another object.
Phases of the Moon	The various shapes of the lighted portion of the moon as seen from the earth.
Seasons	Periods of the year known by differences in the amount of heat received from the sun.
Eclipse	An event that occurs when the earth's shadow falls on the moon (lunar eclipse), or when the moon's shadow falls on the earth (solar eclipse).
Gravity	The force of attraction between the earth and another object.
Tides	The periodic (twice daily) rising and falling of the ocean.

Investigations

Instructional Objective

Given reference books and other media, describe and compare the properties of the sun, the moon, and the earth.

Concepts

Sun, moon, earth
Properties
Planet

Materials needed:

- reference books
- filmstrips, sound films, pictures
- data sheet

Learning activities:

1. Have students observe the sun and the moon and list their properties. Caution them not to look directly at the sun. It could injure their eyes permanently. Ask questions such as the following to help generate ideas. "What color is the sun? What color is the moon? Are their colors always the same? How can you locate the sun without looking at it? What shapes may the moon have?"

2. Have students use books and other media to find information about the sun, the moon, and the earth. Have them take notes and write important facts about the sun, the moon, and the earth. Introduce the word "planet" and discuss the earth as a planet.

3. Have students record data on a chart like the one below. Have them compare information found in different sources.

	Sun	Moon	Earth
Color			
Diameter			
Shape			
Temperature Range			
Surface Feature			
Distance from Earth			
Age			
Gravity			
Mass			
Motion			
Composition			

Instructional Objective | Concept

Given appropriate materials, construct a scale model of the earth and the moon.

Scale model

Materials needed:

wooden bead, 1 inch in diameter
wooden bead, 1/4 inch in diameter
twine

Learning activity:

# Have students construct scale models of the moon and earth with wooden beads. (Other available spheres such as styrofoam, rubber, or plastic balls will work as well.) Have students calculate how long the piece of twine should be to represent the scale distance between the sun and the moon. (Divide the distance of the moon from the earth in miles, by the diameter of the earth in miles. The answer is approximately 51 inches. Have them attach one end of a piece of twine to a 1/4 inch bead and the other end to a 1 inch bead.

Help the students calculate the diameter of a ball needed to represent the sun and how far away it should be placed to represent the distance of the sun from the earth. (The ball would be approximately 9 feet in diameter and 1,100 feet from the earth model.)

Instructional Objective | Concepts

Given appropriate materials, demonstrate and explain the rising and setting of the sun.

Relative motion
Real motion
Daylight
Night

Materials needed:

globe
clay
light source
yellow construction paper
window stick

Learning activities:

1. Make the capital letters N, S, E, and W, about 25 cm high, from construction paper. Fasten each letter to the appropriate wall to represent the directions north, south, east, and west. Make a large yellow circle of construction paper to represent the sun. Fasten it to the end of a window stick. Using the circle as a model of the sun and the room as a frame of reference, have students demonstrate how the sun appears to rise in the East, move across the sky and set in the West each day. Ask them if the sun really moves this

way each day or if it is something else that is causing it to appear to move. Introduce and discuss the concepts of relative and real motion.

2. Place a piece of clay on the globe at the approximate location of Cincinnati. Place the globe approximately three meters from a light source. Place the globe so the North Pole is inclined toward the north wall. Pull the shades and turn off all other lights. As the earth is rotated have the students decide which direction the earth must turn so that, at Cincinnati, the sun would appear to rise in the East and set in the West.

3. Have the students also use the globe and light source to indicate when Cincinnati is having daylight and when it is having night. Have students explain how the earth's rotation causes the earth to have periods of daylight and night.

Instructional Objective	Concepts
Given appropriate materials, demonstrate rotation and revolution.	Rotate Revolve Axis Pole Meridian Orbit

Materials needed:

objects that rotate or revolve, such as: top, clock, pencil sharpener, wheel, ball on a string

Learning activities:

1. Have students demonstrate rotation and revolution with their own bodies. Let them spin in place and walk around one another. Develop the meaning of the words "rotate" and "revolve." Have them describe each of these motions and distinguish one from the other.

#2. Have students name familiar objects that rotate or revolve. Collect some of these objects and have students count rotations and revolutions. Some useful examples are as follows:

   a. How many turns of a pencil sharpener does it take to sharpen a pencil? Are these rotations or revolutions?

   b. How many complete turns does the second hand of a clock make in a class period? How many complete turns does the minute hand make during the school day? Are these rotations or revolutions?

   c. How can you count the rotations of a top? How many rotations will a top make before it stops? How many rotations per second does a top make?

d. What toys, tools, appliances, or vehicles have rotating or revolving parts? What is the meaning of r.p.m? Which of the objects named have r.p.m. ratings.

3. Have students use their bodies to demonstrate the moon revolving around the earth and the earth revolving around the sun. Ask, "Does the moon rotate as it revolves? How can you tell that the earth rotates? If you revolve but do not rotate how many sides of the room do you face? When you rotate, how many sides of the room do you see?"

Introduce and discuss the concepts of "poles," "meridian," and "orbit."

Use a ball, a globe, and a lamp to demonstrate the motions of the moon and earth as they revolve around the sun.

Instructional Objective	Concepts
Given a model of the earth as a frame of reference, demonstrate the concepts of up and down.	Up Down Frame of reference

Materials needed:

- balls
- a globe
- tooth picks
- clay
- paper arrows

Learning activity:

Have students use a ball or a globe as a model of the earth. Let them make stick figures with tooth picks using balls of clay for the heads. Have them use the stick figures and the earth models to show the position of a person standing on the earth. Define "down" as being toward the center of the earth and "up" as being away from the center of the earth.

Have the students stand the stick figures on their desks and place a paper arrow along side them to point downward. Then have them place the figures on the balls once more to show the position of a person standing on the earth. Let them try it in several locations such as the North Pole, the South Pole, or the Equator.

Introduce and discuss the concept of "frame of reference." Have the students name the frame of reference they used when indicating the direction of up or down on their desks and on the earth model.

Instructional Objective	Concept
Given appropriate materials, record the shape and the position of the moon over a specific period of time.	Phases of the moon

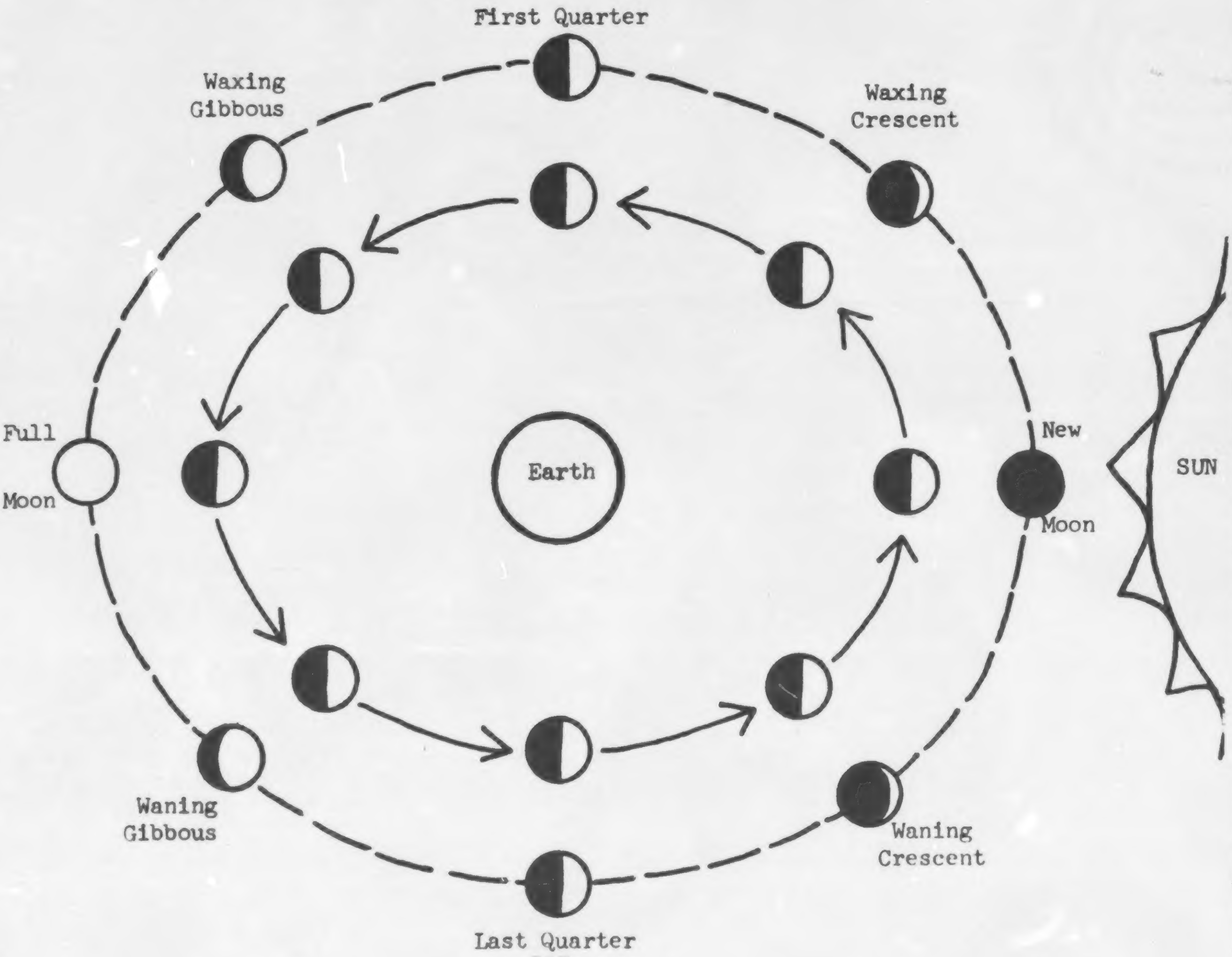
Materials needed:

calendar (pupil made)
almanac

Learning activity:

Have students observe the moon over a period of time such as a week, ten days, or a month. Let them draw pictures of the moon and place them on a calendar. Have them also use an almanac to find the time of moon rise and moon set and place these times on the calendar under the pictures. When the moon is visible during the daytime, help students use a compass to indicate the position of the moon. If students include this information on the calendar, make certain that they also include the time of the observation.

The outer ellipse represents the moon's orbit as it would appear from the earth. The inner circle represents the moon's orbit as it would appear from distant in space.


First Quarter
Waxing Gibbous
Waxing Crescent
Full Moon
Earth
New Moon
SUN
Waning Gibbous
Waning Crescent
Last Quarter

Instructional Objective	Concept

Instructional Objective	Concept
Given appropriate materials, demonstrate the phases of the moon.	Phases of the moon

Materials needed:

filmstrip projector
white, round balloon or ball

Learning activity:

Darken the room. Place a filmstrip projector at one end of the room and a child representing the earth near the other end of the room. Use a white balloon or a ball representing the moon. Have another child hold the "moon" at arms length and make it revolve around the "earth." Have the child representing the earth observe and describe the shape of the lighted portion of the"moon" as it revolves around him. It should be possible for several students to observe this at once.

Instructional Objective	Concept
Given appropriate materials, record the shape and the position of the moon over a specified period of time.	Phases of the moon

Materials needed:

earth - moon model
globe
ball
filmstrip projector or other light source

Learning activities:

1. Have students use the earth - moon model they constructed earlier and a light source to demonstrate eclipses. A globe and a tennis ball also works well. Have them move the moon model across the light source so the moon's shadow moves across the earth model to illustrate a solar eclipse. Have them move the moon model across the shadow cast by the earth model to illustrate a lunar eclipse. Let them draw pictures to illustrate how the sun, moon, and earth are lined up during each type of eclipse.

   Ask the students to indicate the phase of the moon in which each type of eclipse can occur.

2. The following can be done as a class demonstration or in a learning station activity.

   Paint one half of a ball of clay white and the other half black. Place it on a stick. Have students revolve the ball, representing the moon, around a model of the earth so that the white side always faces a model of the sun. Have the child identify the position of the new moon, first quarter, full moon, and last quarter.

Instructional Objective	Concept
Given appropriate materials, demonstrate the cause of seasons.	Seasons

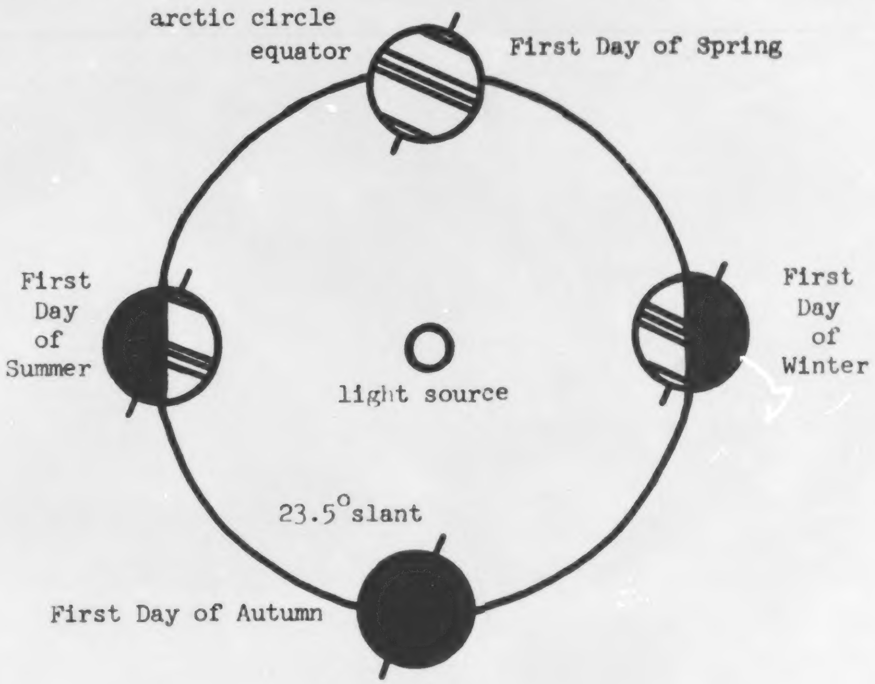
Materials needed:

large sheet of paper
globe
lamp or other light source

Learning activity:

Use a globe to represent the earth. Draw a circle about 80 cm in diameter on a large sheet of paper. Place a lamp or other light source in the center of the circle approximately 10-15 cm above the paper. Place the globe on the circle on the north side of the lamp. Orient the globe so that it is inclined toward the north. Mark that point on the circle December 22. This represents the first day of winter. Observe the part of the globe that is in daylight and the part that is night. Place the globe in each position shown below. For each position ask, "Which part of the earth receives more daylight, the northern half or the southern half? In which part of the earth are the sun's rays slanting more?"

Try the same demonstration placing the globe in a vertical position (without the slant) and observe what effect that would have. Discuss how the tilt of the earth, the curvature of the earth, the earth's rotation, and the earth's revolution help cause seasons.



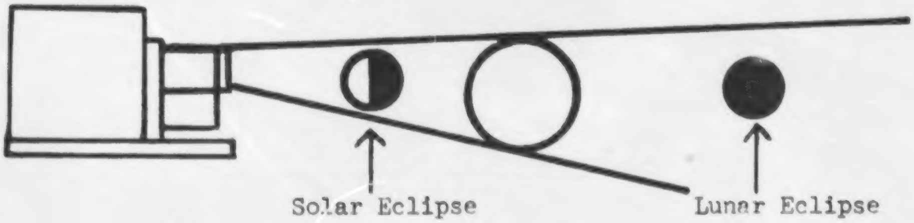
Instructional Objective	Concept
Given appropriate materials, demonstrate the eclipses of the sun and the moon.	Eclipse

Materials needed:

- globe
- light source (lamp with shade removed, filmstrip projector)
- ball (tennis or styrofoam)
- twine

Learning activity:

Attach a piece of twine to a ball representing the moon. Place a globe and light source so that the light falls evenly on the globe. Revolve the moon around the globe in a counter-clockwise direction, keeping moon in beam of light.



Have the children describe the path of the moon's shadow on the earth. Identify this as a solar eclipse - the eclipse of the sun. Ask the pupils to describe what this would look like from the earth.

Have the children describe what the lunar eclipse would look like from the earth.

Instructional Objective	Concept
Given an object, demonstrate the effect of gravity upon it.	Gravity

Materials needed:

- balls or other objects
- balance (spring, pan, or equal arm)
- pendulums
- inclined plane

Learning activities:

1. Provide students with balls or other objects they may drop safely. Instruct them to drop the objects and report what they observe. Instruct them to weigh objects and record the weights.

Introduce the concept of "gravity" and define it. Emphasize that falling and having weight are evidences of the force of gravity.

2. Have students throw objects into the air and describe the path of the object. Ask, "At what point is the object moving the fastest? Where is it moving the slowest?"

The differences in the speed of rising and falling objects is difficult to detect unless the action can be slowed in some way. Have students observe balls rolling up and down an inclined plane. Have them observe a pendulum moving back and forth. Ask the same questions as before.

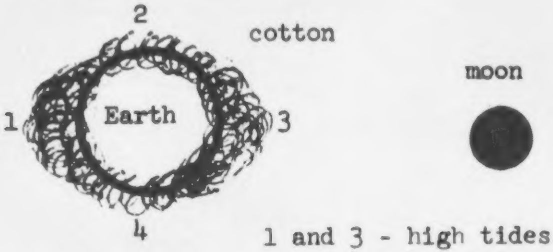
Instructional Objective	Concept
Given appropriate materials, demonstrate the position of the sun, moon, and earth during tides.	Tides

Materials needed:

- cotton
- blue ink (or substitute)
- glue
- construction paper (green, dark blue, yellow)

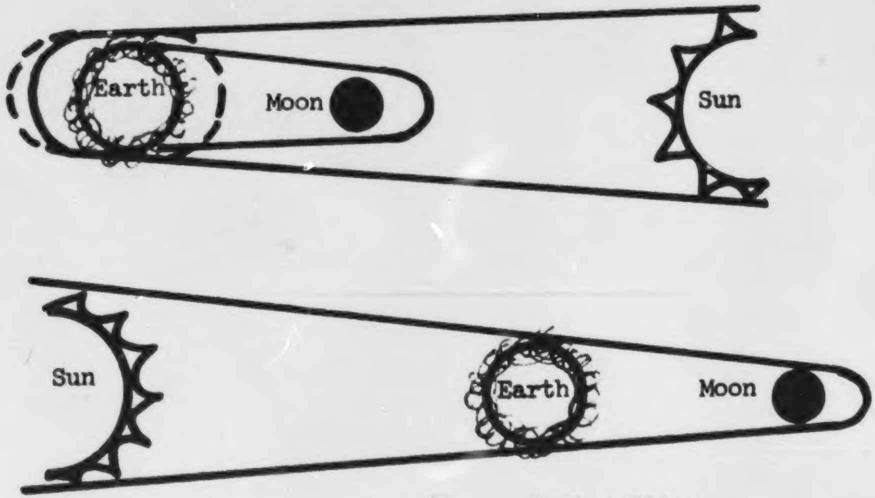
Learning activity:

Draw a large circle (to represent the earth) on construction paper. Shape cotton and glue it around the circle. The cotton, when colored with ink, will give the effect of blue waters. Draw a smaller circle to represent the moon and place it near the earth. Pull cotton on side of the "earth" nearest the "moon." This bulge represents a high tide. Pull cotton on the opposite side to represent a second high tide. The top and bottom will flatten out to form low tides.



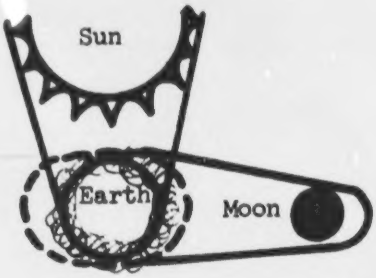
1 and 3 - high tides
2 and 4 - low tides

Spring tide (very high tides). Cut out another circle and label it the "sun." Place the sun to the right of the "moon" and create a spring tide.


Earth
Moon
Sun
Sun
Earth
Moon

Spring Tides

Neap tides (very low tides). Place the sun model above the earth model at right angles to the moon model to create a neap tide.


Sun
Earth
Moon

Neap Tide

Discuss the position or shape of the moon during a spring tide and a neap tide.

(Spring tide - new or full moon)
(Neap tide - last or first quarter moon)

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

626	Earth's Movements
2401	Gravity: How It Affects Us
515	How We Study the Sun
2105	Ocean Tides - Bay of Fundy
1878	Our Big, Round World
942	Sun: Friend or Foe
1782	What Causes the Seasons?
412	What is an Eclipse?

Filmstrips

6492	Earth and Its Neighbors in Space, The Moon
6491	Earth and Its Neighbors in Space, The Sun
7310	Earth and Its Neighbors in Space, Our Earth
6820	Exploring the Moon

A-V Media Approved for Purchase

Filmstrips

Jam Handy

Introduction to the Globe (5 Filmstrips)

Up and Down
Night and Day

Society for Visual Education

True Book Physical Science (6 Filmstrips)

Seasons
Moon, Sun, and Stars

Wards Natural Science Establishment

Basic Astronomy (6 Filmstrips)

The Earth
Rotation
Revolution
Measuring Time
The Moon

Sound Filmstrips

Society for Visual Education

Understanding Our Earth and Universe (6 Filmstrips/ 3 Cassettes)

- The Sun and Its Energy
- The Moon and Its Relation to Earth
- The Moon and Its Movements

Viewlex Educational Media

Moon Rocks (1 Filmstrip/1 Cassette)

Loop Films

Bailey Film Associates

- Space Science:Eclipse of the Moon
- Space Science:Eclipse of the Sun

Doubleday Multimedia

Night and Day

Study Prints

Encyclopaedia Britannica Educational Corporation

Day and Night and the Seasons

Instructional Supplements

Forces of Nature (6 Study Prints/Set)

Earth Movements

Our Natural Environment (6 Study Prints/Set)

Astronomy

Transparencies

Hubbard Scientific

Astronomy (1 Transparency Per Title)

- Day and Night
- Moon
- Eclipses
- Seasons

THE SOLAR SYSTEM

Background

The solar system is composed of the sun and the objects that revolve around it. These objects are the nine planets and their moons, comets, meteors, and asteroids. The solar system is nearly circular and is part of the Milky Way Galaxy, which is also nearly circular. The distance across the solar system is approximately seven billion miles.

Planets. Planets vary a great deal in size, mass, density, gravity, distance from the sun, rotation time, revolution time, number of moons, composition, and other properties. Planets also have many similarities. They all are spherical in shape, have slightly elliptical orbits, and revolve in relatively the same plane. The rotation time of a planet determines the length of its day and the revolution time determines the length of its year. The major planets (Jupiter, Saturn, Uranus, and Neptune) are composed largely of ammonia, helium, hydrogen, and methane. They contain less iron and rock than the terrestrial planets (Mercury, Venus, Earth, and Mars). Little is known about Pluto because it is so far away.

Comets. Comets are thought of to have solid centers surrounded by particles of dust, ice, and frozen methane and ammonia. Comets move close to the sun then far out into the solar system in long, elliptical orbits. As a comet nears the sun, a tail forms. The tail recedes as the planet moves away from the sun. The tail always points away from the sun. It is believed that radiation and fast moving particles from the sun force out some of the comet's materials, forming the tail.

Meteors. Meteors are small pieces of iron and dust. When they enter the earth's atmosphere they burn and are commonly known as "shooting stars." After hitting the earth they are called "meteorites."

Asteroids. Asteroids are relatively small and irregularly shaped. Only a few are larger than 100 miles across and many are less than one mile across. Most of the asteroids are in the "asteroid belt," between the orbits of Mars and Jupiter.

Force in the Solar System. Newton's laws of motion help us understand how the forces of gravity and inertia act upon the planets to keep them in orbit. The first law of motion says that an object at rest will remain at rest unless some force starts it moving, and an object that is moving will continue to move in the same direction and at the same speed unless some force makes it change direction or speed. If only inertia were acting upon a planet, it would travel straight into space. According to Newton's law of universal gravitation, objects in the universe attract one another. The greater the mass of an object the greater its pull on another body. The sun has more mass than any of the planets, therefore the sun's gravitational pull on any planet is greater than the planet's gravitational pull on the sun. If only gravity interacted with the planet, the plant would be pulled into the sun. However, inertia and gravity both interact with a planet, causing it to travel around the sun.

Rationale

In this unit, children will (1) describe planets and other bodies by their properties, (2) construct models and charts, (3) investigate the forces at work in the solar system, and (4) compare hypotheses of the formation of the solar system.

The unit is designed to help students perceive themselves and the earth in relation to other objects in the solar system. Children wonder about the objects they see in space. They are curious about what these objects are, how they got there, and how they affect us. They have had many experiences with objects and events they can see and manipulate. The objects and distances in the solar system are of a magnitude far beyond the normal experiences and perception of children. As such, they become abstract. Models are used to help children perceive the solar system.

Glossary of Concepts

Planet	One of nine major bodies that revolve around the sun.
Solar System	The sun and all the bodies that revolve around it.
Rotate	To spin in place like a top.
Revolve	To move around another object.
Orbit	The path of one object revolving around another object.
Phase of a Planet	The shape of the visible, lighted portion of a planet.
Gravity	The force of attraction between a planet and the sun.
Gravitation	The mutual attraction that all bodies in the universe have to one another.
Inertia	The property of an object causing it to remain at rest, or in a straight line at a constant speed.
Ellipse	An oval-like shape; the shape of the orbits of most heavenly bodies.
Comet	A body made of dust and frozen gases that revolves around the sun in an elongated elliptical orbit.
Meteor	A small piece of matter in space.
Meteorite	A meteor that reaches the surface of the earth.
Asteroid	Relatively small bodies between the orbits of Mars and Jupiter.

Investigations

Instructional Objective	Concept
Given reference materials, find and record properties of planets on a chart.	Planet

Materials needed:

reference books and other media

Learning activity:

Let the class decide what information to put on a chart of the planets. Provide many reference sources and instruct them to record the information on the chart. In addition to individual charts, students may wish to make a class size chart for the bulletin board.

Instructional Objective	Concepts
Given a chart of the planets, calculate what one's age and weight would be on various planets.	Planet Properties of planets

Materials needed:

planet chart

Learning activity:

Using the information in the revolution column of the chart, have the children compute their ages if they lived on the other planets. Using the information in the gravity column of the chart, have the children compute their weights if they lived on other planets.

Instructional Objective	Concept
Given reference sources, infer the likelihood of life on other planets.	Planets and life

Materials needed:

reference sources
planet chart

Learning activity:

# Have children locate facts about temperature, atmosphere and water on other planets. Discuss and determine what life as we know it on Earth needs. Do these conditions exist on other planets? Lead the students to make inferences about the likelihood of life on other planets. Also, ask them how the earth is suited for life.

PLANET CHART

PLANET	DIAMETER IN MILES	DIAMETER IN KILOMETERS	MASS (EARTH = 1)	GRAVITY (EARTH = 1)	AV. DISTANCE FROM SUN IN MILLIONS OF MILES	AV. DISTANCE FROM SUN IN MILLIONS OF KILOMETERS	ROTATION (EARTH UNITS)	REVOLUTION (EARTH UNITS)	MOONS
Mercury	3,100	4,960	.056	.37	36.0	57.6	59 days	88 days	0
Venus	7,700	12,320	.817	.86	67.2	107.5	243 days	224.7 days	0
Earth	7,926	12,681	1.000	1.00	93.0	148.8	23.9 hours	365.3 days	1
Mars	4,200	6,720	.108	.37	141.5	226.4	24.6 hours	687.0 days	2
Jupiter	88,770	62,032	318.000	2.53	483.4	773.4	9.8 hours	11.9 years	13
Saturn	75,100	120,160	95.2	1.07	886.0	1,317.6	10.2 hours	29.5 years	10
Uranus	29,200	367,200	14.5	1.03	1,782.0	2,851.2	10.8 hours	84.0 years	5
Neptune	27,700	343,200	17.2	1.4	2,792.0	4,467.2	15.8 hours	164.8 years	2
Pluto	3,500	5,600	.93(?)	?	3,664.0	5,862.4	6.4 days	247.7 years	0

Instructional Objective

Given appropriate materials, make a scale model of the solar system.

Concepts

Solar system
Rotate
Revolve
Orbit

Materials needed:

planet chart
construction paper
scissors
newspaper
tape measure
balloons
wheat paste
chalk
white wrapping paper (cut in half lengthwise)

Learning activities:

1. Have students compute the diameters of circles needed to represent the diameters of planets to scale. Place these on a data sheet. Use a scale that suits the teacher and the students. The following data sheet uses scales of 16,000 miles to the inch and 10,000 kilometers to the centimeter.

Planet	Scale Diameter in Inches	Scale Diameter in Centimeters
Mercury	1/4"	.31
Venus	1/2"	.77
Earth	1/2"	.79
Mars	1/4"	.42
Jupiter	5-1/2"	8.87
Saturn	4-3/4"	7.51
Uranus	1-3/4"	2.92
Neptune	1-3/4"	2.77
Pluto	1/4"	.35
Sun	54"	138.

Have students cut out paper circles representing each planet. Ask the students how far the earth model would be placed from the sun if the distance were to the same scale as the diameters.

93,000,000 16,000 = 5,812 inches

Ask how many feet there would be in 5,812 inches. Then ask if a model of the solar system to this scale could be placed in the room, in the hall, or on the playground.

The model of the sun and only the first 3 or 4 planets may fit in the hall or on the playground. Ask what they might do to display the model in the room. One solution is to make one chart representing the sizes of the planets and another one to different scale, representing the distances of planets from the sun.

2. Have the students make another chart showing the distances of the planets from the sun. Make it on white wrapping paper 15 inches wide. Use a scale of 10 million miles to the inch or if the teacher prefers, use a scale of 10 million kilometers to the centimeter. Make a data sheet as before. The planets may be represented by a mark on a number line or by small planet models such as the ones above may be used. If this latter is done, make sure the students know that the scale of the planet models are different from the scale of distances.

   Scale: 10,000,000 miles to the inch and10,000,000 kilometers to the centimeter.

Planet	Scale Distance From Sun in Inches	Scale Distance From Sun in Centimeter
Mercury	3-1/2	5.8
Venus	6-3/4	10.8
Earth	9-1/4	14.9
Mars	14-1/4	22.6
Jupiter	48-1/4	77.34
Saturn	88-1/2	131.6
Uranus	187-1/4	285.1
Neptune	279-1/4	446.7
Pluto	366-1/2	586.2

3. Have students tear newspaper into strips 2 cm to 5 cm wide. Mix wheat paste with water until mixture is consistency of thin paste. Have students inflate balloons to proper size to represent each planet. For smaller planets, newspaper may be

shaped into a ball. Cover the balloon or newspaper with the strips of newspaper dipping each strip into the past mixture before applying it to the balloon or newspaper. Apply 3 coverings, then allow to dry and then apply 3 more. These may be painted then hung in the room in the proper order.

This activity provides the opportunity for a group of students to organize itself for a task. The teacher should emphasize the importance for the division of labor in getting a task done.

4. Choose one student to represent the sun and others to represent each of the planets. Have the student representing the sun stand in the middle of the playground. Measure the proper distances and place the planets in the proper places. Use a scale of 10,000,000 miles to the inch or 10,000,000 kilometers to the centimeter. If feasible, chalk lines may be drawn to show the orbit of each planet. The students may rotate and revolve around the sun to show the movement in the system. If desired, each student may carry or wear a sign with the planet's name on it.

Instructional Objective	Concept
Given appropriate materials, illustrate how people see the planets by reflected light.	Reflected light Phase of a planet

Materials needed:

- shoeboxes
- small balls
- twine
- flashlight or other light source

Learning activities:

1. Cut a small hole in one end of the shoe box. Cut another hole the same size in the middle of one side of the shoe box. Suspend the ball from the top of the shoe box. Cover the hole in the side of the box. Look through the hole in the end of the box. Can the ball (representing a planet) be seen? Uncover the hole in the side of the box. Shine the flashlight through this hole. Look through the hole in the end of the box. Can the planet be seen? What makes the difference?

2. Use a ball to represent a planet. Darken the room. If possible, use a closet or room that can be completely darkened. Have a student hold the ball over his head in the darkened room. Can the planet be seen? Use a light source to represent the sun. Shine the light on the ball. What happens when sunlight shines on a planet?

   Discuss the concept of "reflected light"; ask how it enables a person to see an object.

3. If possible, clear the center of the room by placing the desks near the walls. Darken the room. Place a light source in the center of the room. Have someone carry a ball around the light source. Ask, "When do you see all the lighted portion of the ball? When do you see half the lighted portion? When do you see none of the lighted portion? What planets would be inside the earth's orbit? What do you think they would look like?"

   Discuss the concept of "phases of planets." Compare planet phases to phases of the moon.

Instructional Objective	Concept
Given an almanac or sky chart, locate planets in the sky.	Planets

Materials needed:

almanac
magazine - Science and Children, or other science magazine

Learning activities:

1. Have children use an almanac or magazines to find out which planets can be seen, when they can be seen, and in what part of the sky they can be seen. Have children use this information to locate the planets in the sky. Have them observe the planets every night for a few weeks. As they observe, they make a record of what time they saw the planet and the position of the planet. The magazine, Science and Children, has a sky map in each monthly edition.

# 2. Ask students how references such as an almanac may be used to help people at home and on their jobs.

Instructional Objective	Concepts
Given appropriate materials demonstrate how inertia and gravity keep the planets revolving around the sun.	Gravity Gravitation Inertia

Refer to the unit on Sun, Moon and Earth System for learning activities about gravity.

Materials needed:

small rubber ball
file card
twine
shoe box or plastic tumbler
coin
small ball or chalkboard eraser

Learning activities:

Have students perform each of the following activities individually or in small groups.

1. Remove one end of a shoe box. Place a ball in the opposite end of the box. Slide the box along a table top with the open end forward. Stop the box suddenly. Have the children describe what happens.

   Develop the concept "inertia."

2. Place an index card over the top of the tumbler. Put the coin on top of the card. Try to place the coin so it is in the center of the mouth of the tumbler. Jerk or snap the card quickly. Let the children repeat the experiment several times. Discuss the results in relation to the concept of inertia.

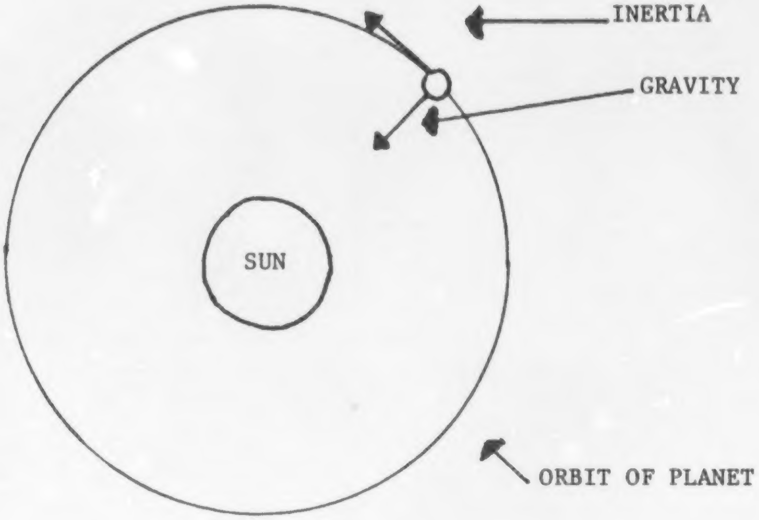
3. Cut a piece of string about 1 meter long. Attach it to a ball or an eraser. Holding one end of the string in your hand, whirl the ball or eraser over your head. Suddenly let go of the string. Discuss how the ball and eraser travel. Refer to activities about the inertia and have students compare the results. It is best to do this activity outdoors.

   Whirl the ball or eraser over your head again. Do not let go. Discuss how the inward pull of your hand keeps the ball or eraser traveling in a circle and from flying straight out. Introduce the concepts, "gravity" and "gravitation." Discuss how the pull of your hand on the string corresponds to the gravitational pull of the sun and how this pull, combined with the force of inertia, act on a planet to keep it in orbit.

Instructional Objective	Concepts
Given a diagram of an orbiting object, explain the forces that keep it in orbit.	Gravitation Inertia

Learning activity:

Show students a diagram such as the one following. Let them explain how the forces of inertia and gravitation keep the planet in orbit. Ask what would happen to the earth if it were to slow down or speed up, and what would happen if the sun's gravity would become greater or less.



Instructional Objective

Given appropriate materials, draw an ellipse to illustrate the orbit of a planet.

Concepts

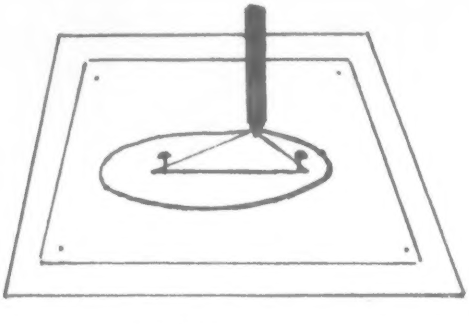
Orbit
Ellipse

Materials needed:

- paper
- flat piece of wood
- small nails
- string
- pencil

Learning activity:

Have students practice drawing ellipses. Provide them with the following instructions. Place a piece of paper on the flat piece of wood. Hammer two small nails into the paper and board. Place a loose circlet of string around the nails. Hold a pencil vertically against the string and pull the string tightly. Keeping the string tight and the pencil straight, move the pencil all the way around the loop of string.



Move one nail slightly toward the other nail. What does this do to the drawing? What would the drawing look like if the two nails were at the same point?

Instructional Objective	Concept
Using reference sources, determine and describe the properties of a comet.	Comet

Materials needed:

reference sources

Learning activity:

# Have students read to determine the properties of comets. They may list these on a chart individually or a class chart may be made.

Compare comets with each other. How long do they take to orbit and return?

The teacher may wish to emphasize the importance of observing similarities and differences in making comparisons to be able to improve children's skill in communicating descriptions.

Instructional Objective	Concepts
Given materials, demonstrate the path that a comet travels.	Comet Orbit Ellipse

Materials needed:

cardboard
black construction paper
facial tissue
string
paper clip
magnet
cut-out sun
yellow or orange construction paper

Learning activity:

Cover a large piece of cardboard with black construction paper. Using a facial tissue, make a small round ball about the size of a mothball for the body. Tie a piece of string below this to shape it. Leave a small section of tissue for the tail. Attach a paper clip to the back of the string.

Cut out a yellow or orange circle of construction paper to represent the sun. Attach it to the center of the cardboard. Draw the planets in their orbits around the sun.

The comet can be held to the cardboard by placing a magnet against the back of the cardboard. Move the comet through the background of the solar system in a parabola shaped orbit, always keeping the tail away from the sun.

Instructional Objective	Concepts
Given reference sources, describe the properties of meteors and asteroids.	Meteor Meteorite Asteroid

Materials needed:

reference sources

Learning activities:

1. Have children read to discover when meteor showers will take place. Have them watch the night sky and record at what time they saw the meteors and in what part of the sky they saw them. They may wish to count the number they see in a certain length of time and calculate how many they would be able to see in an hour and in a day.

# 2. Visit the Museum of Natural History to examine meteorities. Make students aware of the people needed to develop and maintain the exhibits.

3. Have the children find information about asteroirds, and describe their properties. Include information on size and location.

Instructional Objective	Concept
Given reference sources, describe and compare various hypotheses of the formation of the Solar System.	Formation of Solar System

Materials needed:

reference sources

Learning activities:

# 1. Have students read, view filmstrips and study pictures pertaining to the various hypotheses of the formation of the Solar System. Let students practice describing these to each other. Let them evaluate the hypothesis in terms of what is known about the Solar System. The students may wish to choose a specific hypothesis and defend or refute it. Also, when possible, have students identify the people who developed a particular hypothesis.

2. Ask students to give their ideas of how they think the Solar System may have been formed. Guide their thinking by asking questions.

How do you think the planets may have been formed?

How do you think they were placed in orbit around the sun?

Why do you think they are all approximately in the same place?

3. For more advanced students, the teacher may wish to present Bode's Law and ask if this might help in formulating a hypothesis about how the Solar System was formed. (See Our Wonderful World, Grolier, Inc., Vol. 9)

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Victor, et al. Science for the Elementary School, "The Solar System." Macmillan Company, 1970.

Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

1808	Solar System
820	The Night Sky

Filmstrips

6489	Earth and Its Neighbors In Space: Solar System
5716	Our Solar Family

Materials listed in "Media Approved for Purchase."

Transparencies

Milliken Publishing Company

"Satellites - Natural and Artificial" (12 Transparencies/16 Masters)
"The Solar System" (12 Transparencies/4 Masters)
"The Sun's Family" (12 Transparencies/16 Masters)

Hubbard Scientific

"Astronomy" (Solar System)

Study Prints

Instructional Supplements

Set 15 Our Natural Environment, "Astronomy"

Loop Films

Bailey Film Associates

Space Science: Comet Orbits

Sound Filmstrips

Society for Visual Education

Space (6 Filmstrips/3 Cassettes)

Exploring the Planets

Sound Filmstrips (Continued)

Society for Visual Education

Understanding Our Earth and Universe (6Filmstrips/3 Cassettes)

Our Solar System

THE UNIVERSE

Background

The universe is all there is. It is mostly empty space dotted with galaxies. A galaxy is a huge mass of stars, dust, and gas that rotates around a center. A galaxy is composed of billions of stars, light years from one another. The Milky Way galaxy, of which our solar system is a part, is approximately 100,000 light years in diameter and takes 200 million years to rotate once.

Other galaxies are millions of light years apart and seem to be moving away from each other.

Stars vary in magnitude or brightness. The magnitude of a star is determined by its size, temperature, and distance from us. The temperature of a star also determines the star's color. To the unaided eye the stars' colors are very difficult to detect.

Telescopes are valuable instruments in studying the heavens. They gather light and bring the image of distant objects closer to us. Astronomers usually study photographs and spectographs made through telescopes rather than actually looking through telescopes. By taking pictures, the telescope can dwell on a particular section of the sky and by the long exposure pick up light from stars that the eye could never see. Spectographs are pictures of the light spectrum of luminescent bodies. These are used to identify the chemical composition of the stars.

Rationale

The unit The Universe is designed to help students (1) use various sources to find information about the universe; (2) use models to illustrate various stellar phenomena; (3) develop a concept of the vastness of the universe; and (4) develop an understanding of the processes and instruments scientists use to study the universe.

Children are usually self-centered individuals. They perceive objects and events from their own frame of reference. They see the sky as an object above them and the earth. In this unit, they will think of themselves and the earth as a part of a system in a vast universe of systems. They will be developing a concept of their own existence from a universal frame of reference.

Glossary of Concepts

Star	Huge ball of hot gas in space that produces its own light.
Magnitude	Apparent brightness of a star; depends upon its temperature, size, and distance from earth.
Apparent Size	The size of an object as perceived by the viewer.

Galaxy	Large collection of stars, dust, and gas held together in a group by the pull of gravity.
Light Year	Distance light travels in one year. Distance from earth to stars are measured in terms of light year.
Triangulation	A method of measuring distances using triangles.
Milky Way	A spiral shaped galaxy in which the earth is located.
Parallax	The apparent shift of an object in relation to a reference object.
Telescope	Device using mirrors and/or lenses used to gather light to bring images of distant objects closer to the viewer.
Refracting Telescope	A telescope that uses only lenses.
Reflecting Telescope	A telescope that uses a concave mirror.
Spectroscope	An optical instrument used to form a spectrum, and to identify the composition of vaporized materials.
Constellation	Stars that appear to be close together as viewed from earth; they seem to resemble familiar objects.
Zodiac	Belt of twelve constellations through which the earth seems to pass in a year.
Astrology	A study of stars which attempts to relate human events to the position of stars.

Investigations

Instructional Objective	Concepts
Given reference sources, (1) find and record the properties of stars and (2) identify the variables that affect magnitude	Star Magnitude

Materials needed:

reference books
filmstrips
films

Learning activities:

1. Have students search in a variety of reference sources to find the properties of stars. Brainstorm to determine what properties they think are important. Make a class chart showing the range of values of star properties.

color	red, orange, yellow, white, blue white, blue
surface temperature	3000°C to over 25,000°C
size	diameter of 5,000 miles to over 800,000,000 miles
magnitude	-7 to +15
types	supergiants, giants, medium-sized, dwarfs, binary, variable
distance	93,000,000 miles to billions of light years

It would also be valuable for the students to locate the names of some stars and record specific information about them on a chart.

Star	Magnitude	Distance from earth in light years	Color	Temp. °C	Diameter in miles
Rigel	-7	880	blue	25,000	26,400,000
Betelgeuse			red	3,000	

2. When the charts are completed have the students look for patterns. Ask what relationships they see. "What color are the coolest stars? the hottest stars?" "What variables seem to affect the magnitude (brightness) of a star?"

Instructional Objective

Given the names of types of stars, describe them.

Concepts

Stars
Properties of stars

Materials needed:

reference books and other media

Learning activities:

1. Have the students use reference sources to find information on different types of stars. Have them list the various types they find and give the properties of each. The properties should include such things as diameter, color, temperature, composition, and special features. Astronomers classify stars by temperature. This classification is presented in most encyclopedias. The following chart will help students record their information.

STAR TYPES	PROPERTIES	EXAMPLES
Binary (double) Star		
Variable		
Giant		
Supergiant		
Medium-sized		
Dwarf		

A study of such a chart will reveal a relationship between color and temperature. If diameters of stars can be found, it is possible to discover a relationship between color and size.

# 2. Ask students to find information on the life sequence of stars. Have an individual or a group develop a project on the topic. They may develop media to illustrate their presentation.

Instructional Objective	Concept
Given appropriate materials, demonstrate eclipsing of binary stars.	Properties of stars

Materials needed:

filmstrip projector
pieces of red, yellow, and blue cellophane (gelatin)
white paper
one incandescent lamp - white
one incandescent lamp - red

Learning activities:

1. Cut a circle of white paper and mount it on the chalkboard. Shine the light of a projector on the white circle. Place pieces of colored cellophane and a piece of paper at various distances in front of the projector. What effect does the cellophane have on the white circle? What effect does the paper have?

   Double or binary stars are usually too close to each other to be seen without a telescope. Astronomers can detect a double star by its variation in brightness. Castor is a six-unit system made of three sets of double stars.

2. Darken the room. At one end of the room turn on a white and red lamp of low wattage (25-40 watts). Rotate one bulb around another. Is there a difference in brightness during the rotation? When is the light the brightest?

3. Have students compare the two models of binary stars. Do they both demonstrate what one might see through a telescope? Is one better than the other? Why?

Instructional Objective	Concept
Given appropriate materials, demonstrate the relationship between the apparent size of an object and its distance from the observer.	Apparent size

Materials needed:

pencil
objects of various sizes and at various distances

Learning activity:

Have students close one eye and hold a pencil at arm's length so they can cover a given object from view with the eraser end of the pencil. Let them try hiding the object from view at different distances. Suggest that they look out the window and see how large an object they can cover from view with the pencil eraser. Ask the students how such a small object can hide from view an object as large as a tree, a house, a large building. Ask the students to give other examples of how they can tell that objects appear smaller the farther they are from us. Introduce the concept of apparent size.

Instructional Objective	Concept
Given the night sky or a picture of the night sky, distinguish differences in brightness of stars and infer the variables that determine the magnitude of stars.	Magnitude

Materials needed:

reference materials
pictures of stars

Learning activity:

Have students look at stars at night, or show them a star chart, and report in class what they saw. Ask how the stars are different from each other. Discuss brightness and the difference in brightness. Introduce the concept of magnitude. Define it as the apparent brightness of a star. Ask, "What might determine how bright a star appears to us?" The variables that determine a star's magnitude are its actual brightness evidenced by its temperature and color, its size, and its distance from us. If students do not name all these, return to the concept later on in the unit.

Instructional Objective	Concept
Given appropriate materials, demonstrate the relationship between temperature and color of an object.	Temperature and color

Materials needed:

propane burner
nail (other metal objects)
tongs

Learning activity:

# The teacher may wish to do the following as a demonstration because of the hazards involved.

Use tongs to hold a metal object, such as a nail or a penny, in the blue part of the flame of a propane burner. Observe the color of the nail as it is heated. What color change occurs as the metal is heated? Does the iron nail produce a different color from the penny?

Scientists are able to determine the temperature of a heated object by observing its color. Have students find other applications for this tenchique. (Check steel, glass, and plastic industries.)

Instructional Objective	Concepts
Given reference materials, find different types of galaxies and their properties.	Galaxy Milky Way

Materials needed:

reference books
filmstrips
films

Learning activity:

Have students read to find different types of galaxies and their properties. They may wish to draw pictures of them and recor their findings on a chart similar to the one below. Be sure to include the Milky Way galaxy and ask why it is important to us.

	Spiral	Elliptical	Irregular
Properties			
Picture			
Example			

Instructional Objective

Given appropriate materials, demonstrate how galaxies move away from each other.

Materials needed:

balloon
marker or pen
reference material

Learning activities:

# 1. Read in reference books to find what evidence there is that the galaxies are moving away from each other. Ask, "If the galaxies are moving away from each other, what is happening to the Universe?" Have the children draw dots on a balloon that has been blown up a little. (The dots represent the galaxies.) After they have drawn several dots around the balloon, have the children blow more air in the balloon. What happens to the "space" between the dots on the balloon?

Instructional Objective	Concepts
Given reference sources, make a chart of distances between specific objects in space and compare them.	Distance in space Light year

Materials needed:

reference sources

Learning activity:

Provide the students with many appropriate reference sources and have them find the distances listed below and record them.

from sun to earth
diameter of Milky Way galaxy
diameter of Pluto's orbit
nearest star (Proxima Centauri)
other stars
from sun to Pluto
distance to other galaxies

Allow students time to think about these distances. Encourage them to express their thoughts orally and in writing. Ask such questions as "Do you think there might be other solar systems? Do you think there may be life on some of them? Do you think man could ever travel to another solar system? Do you think man could ever travel to another star? Do you think man could ever travel to another galaxy?"

Instructional Objective	Concept
Given the definition of a light year, calculate its distance in miles.	Light year

Materials needed:

pencil and paper
reference sources

300

Learning activity:

Have students find the speed of light in a reference source. Using 186,000 miles per second, have the students calculate how many miles light would travel in a minute (60 x 186,000). Using this figure and a planet chart, calculate how long it takes the light of the sun to reach various planets. (It takes the sun's light approximately 8 minutes to reach the earth, approximately 80 minutes to reach Saturn, and over 5 hours to reach Pluto.)

Have students find the distance to the nearest star. (The nearest star is Proxima Centauri and is over 4 light years from our solar system.) Compare this distance to the distance of the planets.

Calculate the distance light would travel in an hour (60 x 60 x 186,000), in a day (24 x 60 x 60 x 186,000), and finally in a year (365¼ x 24 x 60 x 60 x 186,000). Discuss the usefulness of the light year in expressing distances in space.

In the metric system, the speed of light is approximately 298,000 kilometers per second.

Instructional Objective	Concepts
Given appropriate materials, demonstrate how the distance of stars can be measured.	Distance of stars Triangulation

Materials needed:

- pencil
- drinking straws
- chart paper or wrapping paper
- protractor (optional)

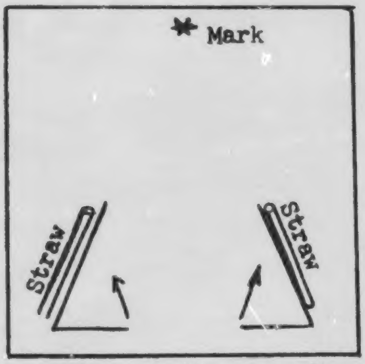
Learning activities:

1. One method of measuring star distances is by triangulation. Use the following instructions to demonstrate triangulation:

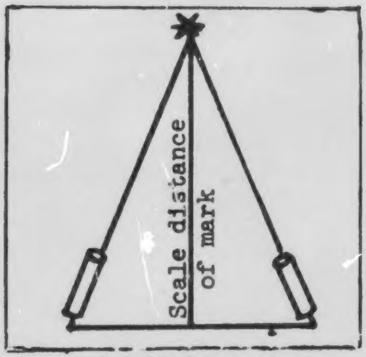
   Make a small mark on the chalkboard. From the opposite end of the room and to one side, sight the mark through a drinking straw. Make a line on a piece of chart paper beneath the straw to measure the angle of the straw. Move across the room, sight the mark again, draw a line on a piece of paper to mark the angle of the straw. Measure the distance between the two sightings. Make a scale drawing of the triangle formed by the mark and the location and angles of the two sightings. The perpendicular distance from the apex of the triangle of its base will be the scale distance of the mark. Try this method to measure the distance of buildings and other objects outdoors.

# 2. Have students find applications of triangles in measuring distances with range finding equipment.

Chart Paper



Measure these angles



Scale distance between sightings

Ask, if sightings were taken of a star 6 months apart, how far apart would those sightings be? (Use the average distance of the sun from the earth, 93,000,000 miles, making the sighting distance 186 million miles.)

Instructional Objective

Given appropriate materials, demonstrate how objects appear to shift position when viewed from different points of reference.

Concept

Parallax

Materials needed:

pencil

Learning activity:

Have students hold a pencil upright at arm's length. Have them look at an object in the room by sighting over the top of the pencil with one eye closed. Have them close the eye that was open and open the other eye. Ask them to report what the pencil appears to be doing. Have them do the same thing holding the pencil close to the eyes. Then have them try it by having someone else hold the pencil a greater distance away. Then ask, "Where does the pencil seem to shift the most--when it is held close to the eye or farther away?"

Some stars are so far away their shift is not measurable. The distance of stars closer to us can be calculated by measuring how far it shifts in relation to its background of more distant stars.

Introduce the concept of parallax and discuss its meaning.

Instructional Objective

Given a picture and diagram of a telescope, (1) classify it as a reflecting or refracting type, (2) describe how it works and (3) name the most important American telescopes.

Concepts

Telescope
Reflecting telescope
Refracting telescope

Materials needed:

pictures and diagrams of reflecting and refracting telescopes
reference materials

Learning activities:

# 1. Show students pictures and diagrams of different types of telescopes or have them find them in reference books. Ask the students to describe the telescopes by their properties. Discuss the advantages of the reflecting telescope. Show students pictures of telescopes and have them identify them as reflecting or refracting, and give evidence for their choice. Give students practice in describing how both telescopes work using diagrams. Have them trace the path of the light and describe what the lenses and mirrors do to the image. Ask students if they were going to buy a telescope, which kind would they buy.

2. Have students find the names of the most important American telescopes.

# 3. Have the students use reference material to find how astronomers actually use telescopes.

Instructional Objective

Given appropriate materials, construct a workable telescope.

Concept

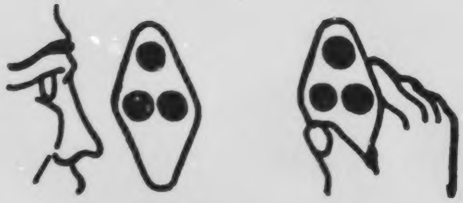
Telescope

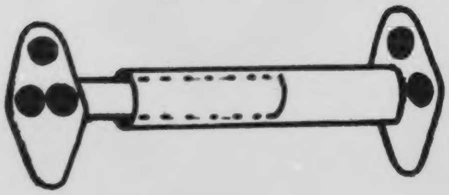
Materials needed:

hand lenses
cardboard tubes
convex lenses

Learning activity:

# The simplest telescope can be made by holding two hand lenses in line with the eye. Have students hold them so that they can view a distant object, such as a church steeple. If the teacher and class desire, the hand lenses may be mounted at opposite ends of cardboard tubes cut the proper length to focus. Tubes that slide within one another would allow students to focus their telescopes on objects at a variety of distances. Separate convex lenses may be purchased if a more sophisticated telescope is desired.





Instructional Objective

Given appropriate materials, demonstrate how vaporized elements are identified by their color on their line spectra.

Concept

Spectroscope

Materials needed:

- diffraction grating replica
- cardborad tubes
- paper (preferably black)
- scissors
- tape
- glass tubing
- nichrome wire (or paper clips)
- sodium chloride or other sodium salt
- calcium chloride or other calcium salt
- lithium chloride
- mercury vapor lamp (if available)
- gas burner
- reference materials

Learning activities:

1. Heat one end of a 5-inch pice of glass tubing until it is soft. Insert one end of a piece of nichrome wire into the softened glass rod, clamp it with a metal clamp, and allow to cool. Make a small loop in the other end of the wire. (A straightened paper clip will work if no nichrome wire is available.)

   Place the wire look into the flame of the gas burner and then into some sodium chloride. Now place it back into the flame and observe the color. Try salts of other metals such as calcium and lithium.

# 2. Make a simple spectroscope as follows:

   Tape a piece of black paper over one end of a cardboard tube. Cut a thin slit in the center of the paper.

Make a hole about 3/4" square in a piece of black paper. Tape a piece of diffraction grating replica over the hole. Orient the lines parallel to one side of the square. Tape the paper over the open end of the cardboard tube so the lines are parallel to the slit at the other end.

Look at the various light sources through the spectroscope. An incandescent bulb and sunlight (do not look directly at the sun) will produce a continuous spectrum.

Look at a mercury vapor lamp (fluorescent) and observe the lines in the spectrum.

Go into a very dark room and observe the spectra produced by sodium chloride vaporized by a gas burner. Try calcium chloride and lithium chloride, if available.

Chemical elements can be identified by their spectra. In this way astronomers can identify elements on the sun and on stars.

# 3. Have students use reference materials to find other uses for spectrography.

Instructional Objective	Concept
Given reference material, find and report how astronomers use radio telescopes	Radio telescopes

Materials needed:

reference materials and media

Learning activity:

# Have students find information on radio telescopes and report how and why astronomers use them. Ask, "What information do they provide that optical telescopes do not?"

Instructional Objective	Concept
Given a representation of constellations, identify them by name.	Constellation

Materials needed:

shoe box
paper
flashcards of constellations (made by children or teacher)
two pictures of 10 dots on chalkboard

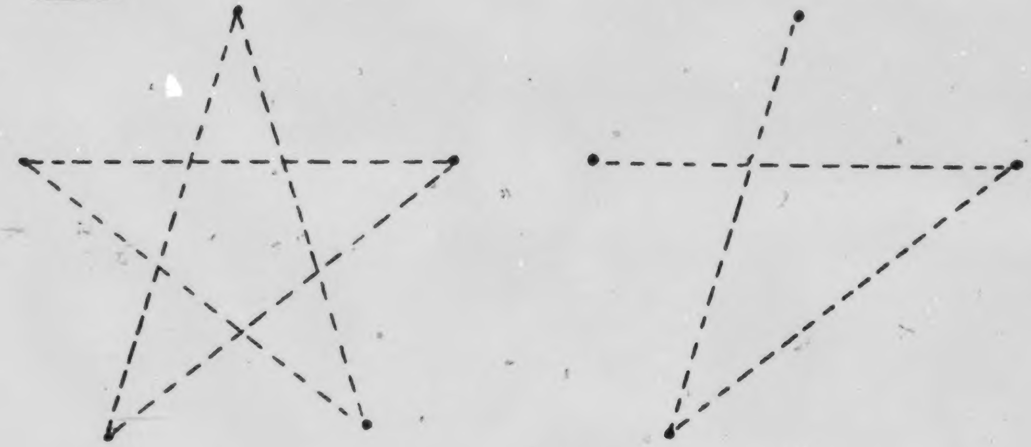
Learning activity:

1. Make an opening at one end of the shoe box (a round cereal box will do, also) about three-fourths of an inch (or about 2-3 cm) in diameter. Remove the other end. Have students make pictures

of constellations by puncturing holes in pieces of paper to represent stars. Have them place the pictures at the open end of the box and view them through the smaller opening at the other end.

Students may use these individually or in pairs to help learn the names of some of the constellations. It would be good for the students to learn the names and configurations of constellations that would be easy for them to locate at night.

2. Put drawings of constellations on flashcards. Let two teams take turns naming the constellations pictured. Draw a line connecting two dots on a five-pointed star for a correct response. Both teams must get the same number of turns. The team that completes the star first wins. Tie games are possible.



TEAM A

Instructional Objective

Given reference books, other media, and appropriate materials, locate, record, and report information on selected topics pertaining to constellations.

Concept

Constellation

Materials needed:

reference books and other media (including World Almanac)
art supplies
protractors
drinking straws
tape
paper tubes

Learning activities:

Finding and naming constellations are not valuable activities in themselves but do help students become familiar with the sky, orient them to directions, and give them a way to locate individual stars and other celestial objects. The following activities may be useful for those students who are especially interested in constellations.

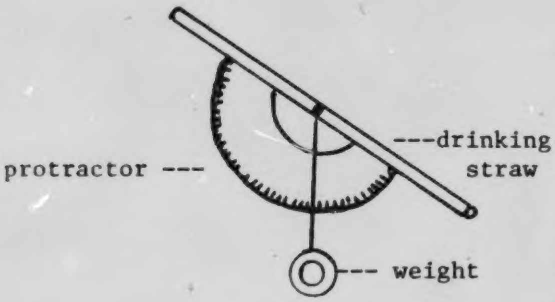
1. Locate the Zodiac constellations. Draw diagrams of their locations throughout the year.

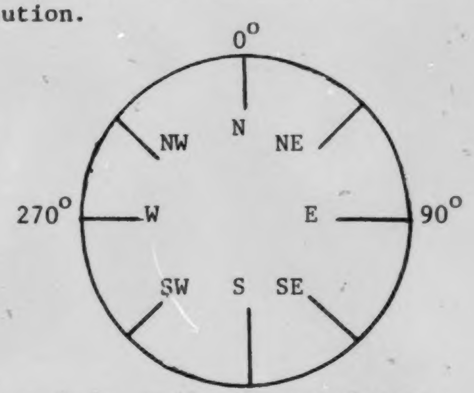
2. Define ecliptic, celestial equator, zenith, azimuth, horizon, altitude (as pertrains to stars), declination, and meridian.

3. Construct a compass rose and a simple astrolabe. Use these to specify the locations of constellations.

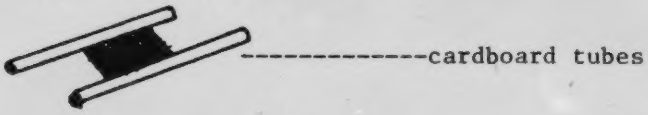
   Tape a drinking straw to the edge of the protractor. Tape a weighted piece of twine to the index of the protractor. View a star through the straw, clamp the twine to the protractor scale with the thumb and read the star's altitude in degrees.

   By placing the weight of the plumb line at the center of the compass rose, the horizontal direction of the star may be read. The two readings will describe the position of the star. However, it is necessary to also include the time and date because of the earth's rotation and revolution.





4. Construct buddy-scopes. Use them to help another person locate a constellation, star, or other object in space.



   Glue tubes together. Tubes are spaced so that one person can look through the left tube while another person looks through the right tube.

5. Investigate myths related to specific constellations. Report or dramatize these to the class.

6. Write myths related to specific constellations.

7. Draw pictures of constellations on large sheets of paper. Place them around the room in approximately the proper location. Label the walls to indicate directions and specify the time of year used to orient the constellations.

Instructional Objective	Concept
Given a sky map, locate specific constellations.	Constellation

Materials needed:

sky maps
reference material

Learning activities:

1. Orient students to sky maps at school--then send the maps home with students so they can practice finding constellations. The sky maps will indicate the location of constellations and will provide pictures so the student will know what to look for. The teacher may wish to meet with a group of students at night to view constellations.

   Choose a night that is dark and clear. If possible, choose a location away from city lights.

   Start with the big dipper. It is probably the easiest to find and helps one locate the north star, Polaris. The other directions can be located using Polaris as the north reference point. Place the sky map overhead. Orient Polaris on the may so it points toward Polaris then look for various constellations.

# 2. Have students use reference materials to find out how constellations and stars are used in navigation. Invite an individual with navigation experience to visit the class and discuss the use of stars, and instruments in his work.

Instructional Objective	Concept
Given appropriate materials, demonstrate why different constellations are seen at different times of the year.	Constellation

Materials needed:

light source
globe
sky map

Learning activity:

Place a light source in the center of the room. Have students stand around the edge of the room representing constellations. Let one child rotate the globe as he moves about the sun. Have him stop several times as he revolves and ask the students which constellation would be visible in the night sky. Ask, "Which constellation can be seen the year round? Which ones could be seen this time of year?"

If the teacher wishes, each student could represent specific constellations and it would be shown why, for example, Orion can be seen during the winter and why Leo can be seen during the summer. A sky map would be helpful in assigning positions to children representing specific constellations.

Instructional Objective	Concept
Given reference materials and horoscopes, make an evaluative judgment concerning the validity of astrology and its use.	Astrology

Materials needed:

horoscopes
reference materials

Learning activities:

#1. Have students use reference materials to find information on astrology; its history and its use. The following questions may be used to stimulate thinking:

- How widespread is astrology?
- What countries rely on astrology in decision-making?
- How has astrology been commercialized in our country?
- What is your opinion about horoscopes? Are they valid? Are they scientific?
- Give your opinion as to whether or not astrology is a science. On what evidence do you base your opinion?
- How does an individual become an astrologer?

#2. Some students may wish to list the characteristics of famous people, and compare these with predictions made, based on their horoscopes.

#3. Have students bring in their horoscopes from the newspapers. Have them keep a record of all that happens to them that day. Do this for several days. Lead students to a decision concerning the validity of horoscopes as predictors.

#4. If possible, let some students interview an astrologer and report to the class.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

4	Constellations, Guide to the Night Sky
2144	Understanding the Universe

Filmstrips

6490	Earth and Its Neighbors in Space: Astronomy Through the Ages
6493	Earth and Its Neighbors in Space: The Stars

A-V Media Approved for Purchase - 1975

Sound Filmstrips

Eye Gate House

Earth Science (10 Filmstrips/5 Cassettes)

Beyond Pluto

Scoiety for Visual Education

True Book Physical Science (6 Filmstrips)

Moon, Sun, and Stars

Understanding Our Earth and Universe

The Stars and Outer Space (6 Filmstrips/3 Cassettes)

Transparencies

Milliken Publishing Company

Outer Space
The Universe

Hubbard Scientific

EA-6 Star Chart (N-Sky) (Astonomy Series)

Charts

Rand McNally

Wall Star Chart

Northern Skies
Southern Skies

Study Prints

Instructional Supplements

Astronomy (Our Natural Environment Series)

SPACE TRAVEL

Background

Space science is a relatively new field. It took billions of dollars, thousands of people, and many years to accomplish the task of putting a man on the moon. Many technological problems had to be solved to enable man to travel in space.

Rocket technology had to be developed. Space capsules and space suits had to be designed and manufactured. Space food, space tools, communication systems, and other materials were developed specifically for use in space. Astronauts received years of specialized training to enable them to be able to function in space.

Many of the principles involved in manned space travel had been known for years. Special conditions in space required innovative approaches to deal with them.

Rocket Principles. As a rocket moves upward it must overcome the force of gravity. A child overcomes gravity as he jumps or throws a ball into the air. These thrusts cannot be maintained because once the child has left the ground or the ball has left the hand there is nothing it can push against. A rocket must produce a steady thrust over a long period of time. This is done as hot, expanding gases push down through the open end of the rocket; pushing the rocket upward. A rocket operates on the action-reaction principle.

A rocket must carry its own oxygen supply. Great heat and pressure is needed to produce the necessary thrust. This requires a rich supply of oxygen. This is often supplied by using liquid oxygen. Also, there is not enough oxygen in the upper atmosphere to sustain combustion. There is little or no air in outer space.

Objects in Orbit. The faster an object is thrown, the farther it will travel before falling to the earth. If an object moves fast enough horizontally it will fall in a circular pattern around the earth. This speed is about 18,000 miles an hour and is called the orbital velocity. The farther an object is from the earth the slower is its orbital velocity. This is because the earth's gravity diminishes as the distance from the earth increases. An object in orbit needs no more fuel to help it move. Its own inertia and the force of gravity enable it to maintain its motion around the earth. There is no air in outer space so there is no air resistance.

An object moving away from the earth at 25,000 miles per hour can escape the earth's gravitational pull. It will move into space in an elliptical path and will not return toward the earth. This speed is called the escape velocity.

Space Vehicles. Space vehicles are capable of carrying an endless variety of payloads. Each space mission is designed to accomplish a specific objective.

Man made satellites are used for mapping, monitoring weather conditions, relaying communications, observing stars, assisting in navigation, and studying conditions in the outer atmosphere and outer space.

Space probes send information back to the earth from great distances. They are used to study other planets and conditions in the far reaches of space.

Rationale

This unit Space Travel is designed to help children (1) understand the principles and purposes of space travel, (2) understand the benefits of the space program, and (3) develop an appreciation of the contributions people have made to space technology.

Space exploits are significant historical events. Children are interested in following these events as they occur. Manned space flight may be a rare occurance in the future, but the use of satellites and space probes have tremendous implications for the future. The special problems, equipment, and people involved in space exploits have a special appeal to children.

Glossary of Concepts

Action-Reaction	A force and its accompanying counter force; for every action there is an equal and opposite reaction (Newton).
Thrust	The force of gases escaping a rocket.
Orbit	The path of an object revolving around another object.
Orbit Velocity	The speed an object needs in order to maintain an orbit.
Inertia	The property of an object causing it to remain at rest or in motion in a straight line at a constant speed.
Gravity	The force of attraction between the earth and another object.
Satellite	An object that revolves around another object.
Space Probe	A space mission that explores a spatial body or condition and reports information back to earth.
Life Support System	Special equipment that provides the environment to sustain the life of astronauts.

Investigations

Instructional Objective	Concepts
Given appropriate materials, demonstrate rocket principles.	Action-Reaction Thrust

Materials needed:

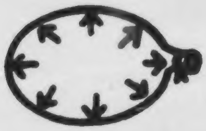
balloons
reference materials

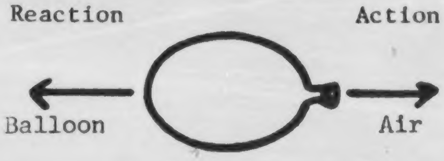
Learning activities:

1. Let a student blow up a balloon. Ask, "What is pushing on the sides? What will happen when the balloon is released? Why?"

   Have the student release the balloon. Ask, "Which direction did the balloon move? Which direction did the air move?"

   Have students draw pictures similar to the one below to illustrate how the balloon was moved.





2. Introduce the concepts of "thrust" and "action-reaction." Define it. Refer to the activities with action-reaction in the unit Force, Motion, and Machines. Have students describe walking, swimming, and rowing a boat in terms of action-reaction.

3. Let students use reference materials to find information about rockets. Some suggested topics are: staging; fuels - solid and liquid; oxidizers; rocket design; mass-ration; and payload. Let students make charts, drawings, and diagrams to illustrate and describe various aspects of rockets.

Instructional Objective

Given appropriate materials, demonstrate how a satellite remains in orbit. (See the unit The Solar System for investigations related to this objective.)

Concepts

Orbit
Inertia
Gravity

Materials needed:

cardboard tube or wooden spool
window shade cord
blackboard eraser
metal washers

Learning activity:

Place a piece of twine through a wooden or cardboard tube. Tie a blackboard eraser on one end of the card and some metal washers on the other end. Hold the tube and swing the eraser around in a circle to lift the metal washers. Ask, "What happens when the speed is increased? How does this affect the orbit? What force keeps the eraser in orbit? What force is resisting it? What force keeps a satellite moving outward? (inertia) What force keeps it from moving on out into space? (gravity)."

Instructional Objective	Concepts
Given reference materials, describe various kinds of space missions.	Satellite Space probe

Materials needed:

reference materials
art supplies

Learning activities:

1. Have students search a variety of reference sources for information about satellites. They may write NASA or call their congressman and request information. Let them collect or draw pictures illustrating the uses of satellites. Classify satellites by use such as communication satellites, surveilance satellites, space stations, space observatories, and weather satellites.

2. Have students find the names of space probes to the moon and various planets. Have them report information learned from these investigations of space.

3. Have students prepare a mural depicting various events that occur during a trip to the moon. Include pre-flight training; blast off; earth orbit; earth escape; docking; orbiting the moon; separation of LEM from command module; descent to the moon; moon landing; moon exploration; ascent and docking; blast off for the earth; re-entry; and rescue of astronauts.

# 4. Have students explore the various occupations related to the space industry. Have them identify products and materials developed by the space industry.

Instructional Objective	Concepts
Given appropriate materials, simulate a space trip.	Life support system Other space terms

Materials needed:

reference books, filmstrips, sound films, and other media
cardboard, paper, and other art supplies

Learning activity:

# Plan a vacation in space. Have students read and view filmstrips, sound films, and other media for ideas and information related to manned space travel. Brainstorm with students to determine what committees will be needed in planning the trip. Also have them identify the task of each committee and set dates for completion of tasks. Have periodic progress reports from each committee.

Some suggested committees are: itinerary; food; life support system; communications; capsule construction; mission control; space suits; and astronaut training.

Have students develop a space glossary. Encourage them to use these terms in their presentation of their vacation in space.

The simulated trip can culminate in a presentation to parents and other classes. They may be invited to "go along." The presentation may include tapes of dialogues between mission control and astronauts, reports on various aspects of space travel, an appropriate movie or filmstrip, and eating space food.

Instructional Objective	Concepts
Given reference sources, report the contributions of people to space science.	Careers Contributions

Materials needed:

reference materials

Learning activity:

# Have each student write a brief statement about the contribution of a specific person to space science. Assemble the statements and place them in a book. Make the book available to the children to read. Share it with other classes in the school.

Some important names which should be included are: Luis Walter Alvarez, Wernker Von Braun, Robert Goddard, Samuel Langley, Orville Wright, Yuri Gagarin, Alan Shepherd, John Glen Jr., and Neil A. Armstrong.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

6	First Men Into Space
2410	Satellites: Stepping Stones to Space
108	Space Flight Around the Earth

Filmstrips

6820	Exploring the Moon
6780	Getting Ready for a Space Trip

Filmstrips (Continued)

6779	Rockets to Space
6818	Space Satellites
6819	Space Stations
6778	What Is In Space?

A-V Media Approved for Purchase

Filmstrips

Jam Handy

First Adventures in Space (3 Filmstrips)

- What Is In Space?
- Rockets to Space
- Getting Ready for a Space Trip

Space and Space Travel (3 Filmstrips)

- Space Satellites
- Space Stations
- Exploring the Moon

Society for Visual Education

Space and Space Travel (4 Filmstrips)

- Leaving the World
- Current Events in Space
- Man in Space
- Space Travel, A.D. 2000

Sound Filmstrips

Coronet Films

Aerospace (6 Filmstrips/6 Cassettes)

- How Rockets Work
- How Satellites Stay in Orbit
- Satellites and Their Work

Eye Gate House

The Space Age (9 Filmstrips/5 Cassettes)

- Pioneers in Space
- Exploration of Space
- Aviation of Space
- The Conquest of Space
- Man Travels in Space
- Hazards in Space Travel
- Destination in Space
- Stations on the Moon

Sound Filmstrips (Continued)

Society for Visual Education

Space (6 Filmstrips/3 Cassettes)

Skylab
Space Shuttle
Interplanetary Space Travel
Satellites at Work
Exploring the Planets
Man and the Moon

Understanding Our Earth and Universe (6 Filmstrips/3 Cassettes)

How Man Explores Space

Loop Films

Bailey Film Associates

Space Science: Experimental Weightlessness
Space Science: Free Fall in Space

Study Prints

Society for Visual Education

The Astronaut - Training and Equipment (8 Study Prints)
Man on the Moon (8 Study Prints)
Preparation for Moon Landing (8 Study Prints)

Transparencies

Milliken Publishing Company

Satellites - Natural and Artificial (12 Transparencies/16 Masters)
Space Travel (12 Transparencies/4 Masters)

Popular Science

Orbiting a Satellite (4 Transparencies/8 Overlays)

LIFE SCIENCE

LIFE SCIENCE

This section, Life Science, is divided into three units: Identifying Life, Investigating Life, and Continuation of Life. The major concepts in the Life Science section are built around organisms, their behavioral and structural characteristics, their needs, their life cycles, and their environment. The major thrust throughout the entire section is ecology - the interrelationships between organisms and their environment.

The activities in the Life Science units provide students with many first-hand experiences with organisms. Teachers should have plants and animals in the classroom and visit facilities in the city where living things can be observed and studied.

Because organisms take time to grow, it is not convenient to restrict their study to a specific block of time. The teacher should feel free to use activities from the Life Science units as changes occur in living organisms in the classroom or outdoors. Aquaria, terraria, and animals in cages make ideal interest centers and should be maintained throughout the school year. Gardening experiences are also valuable. If space is not available outdoors, provide a miniature garden in a tub or planter within the classroom.

It is essential that children develop healthy attitudes toward the environment. People have dominated life on Earth in many ways. They have cultivated crops, hunted and fished, raised animals, and extracted many of the earth's natural resources. In the effort to provide for their needs, people have often interfered with the natural cycles and polluted the environment. They have put extra demands on the world's food and energy supply through over population.

Children must develop responsibility for the wise use of the environment. They must develop a healthy respect for life. They must be taught to respect wildlife and be encouraged to leave animals and plants in their natural environments. Classroom experiences with organisms, caring for plants and animals, and observing them over a period of time, should help children learn to appreciate and conserve the natural environment.

IDENTIFYING LIFE

Background

Organisms. Organisms are individual living things. They can be distinguished from non-living things in that they breathe, require food, grow, move, reproduce, and respond to stimuli.

Characteristics. Non-living things are distinguished from one another by their properties. Organisms have properties also, but they are usually referred to as characteristics. Characteristics may be structural or behavioral. Although this unit stresses structure more than behavior, it is natural for students to be interested in the function of the structural parts of organisms. For example, mammals breath with lungs, fish breathe with gills, and plants take in water and minerals through their roots. Behavioral characteristics and the function of structural adaptations are treated in greater detail in the unit, Investigating Life.

Diversity. Living things are different from one another in their physical characteristics and in their behavior. They vary in size, color, coverings, environment, food, duration of life, mode of travel, extent of travel, habits, and in many other ways. There is diversity among offspring having the same parents. Examples of diversity can even be found within a specific organism.

Classification. Organisms may be classified by their characteristics. All living things may be divided into one of two main classifications: plants and animals. Most plants are easily distinguished from animals. However, some animals, such as sponges and coral, live in colonies that resemble rocks or plants. The euglena is a microorganism that moves about like an animal but contains chlorophyll and makes its own food like a plant.

Although scientists have classified ten major groups of plants and nine major groups of animals, it is not necessary that intermediate age students deal with these. The emphasis at the intermediate level is on observing similarities and differences among living organisms and having students devise their own classification systems.

Rationale

The unit, Identifying Life, is designed to help students (1) identify the characteristics of living organisms that distinguish them from non-living things, (2) identify similarities and differences among the various forms of life, and (3) classify living organisms by their characteristics.

At the intermediate level, children are usually interested in doing things with plants and animals. They like to observe and care for living organisms. This unit provides many experiences for students to investigate similarities and differences among organisms. It provides opportunities for students to make gross and fine discriminations, to develop knowledge and appreciation for the wide variety of many forms of life, to devise systems of classifying organisms, to build an appreciation for the life support system in a given environment, and to develop a healthy respect for life.

Glossary of Concepts

Organism	An individual living thing, plant or animal.
Culture	Organisms being cultivated or reared for supply.
Habitat	The place where an organism usually lives.
Characteristic	A property or attribute of an organism.
Structure	A part of an organism. The way an organism is built.
Behavior	The way an organism does things.
Adaptation	A structure or a behavior of an organism that enables it to live in its environment.
Living	Having life, that state of being alive that exists between conception and death.
Environment	All the objects and conditions that influence the growth, development, and reproduction of organisms.
Survival	Continuation of life.
Organic	A material that is now or has been part of a living organism.
Inorganic	Material not derived from living organisms.
Classification	An arrangement of objects or organisms into groups according to some characteristic or criteria.
Cell	The basic unit of which organisms are composed.
Plant	One of the two main classifications of organisms; a living organism having cell walls of cellulose. Most plants have unlimited growth, manufacture their own food, and are not capable of voluntary motion.
Animal	One of the two main classifications of organisms; organisms whose cells lack walls of cellulose, and most of whom are capable of moving at will.
Diversity	The difference in properties of objects and organisms.
Pattern	A design that is typical of an object or organism. There are patterns of shape, color, and repetition.
Change	Differences in objects and organisms that occur over a period of time.

Investigations

Instructional Objective	Concept
Given appropriate materials and outdoor sites, identify objects that are organisms.	Organism

Materials needed:

access to a variety of habitats outdoors
pictures, filmstrips, films showing various habitats
terraria and aquaria

Learning activities:

The following strategies may be used to help students identify objects as organisms and to help them identify some organisms by name.

1. Take students on an organism hunt either around the school community or local park. As they find living objects refer to them as "organisms." Encourage general use of the term throughout the unit.

2. Have students identify organisms by name and keep personal lists of them. Encourage pupils to collect pictures of organisms from magazines. Have them make card collections by pasting the pictures on one side of a file card and printing the name of the organism on the other side.

3. Send students on an organism scavenger hunt. If any of the items should not be picked up or collected, ask them to tell where the organism is located. This encourages children to be ecology minded. Include non-living objects that are related to organisms such as worm castings, bird nests, and ant hills. Assign points for specific items. Give a prize to the student or team getting the highest number of points.

   Organisms and other objects that may be included in the scavenger hunt are:

   - maple leaf
   - oak leaf
   - grass leaf
   - grass flowers
   - grass seeds
   - maple seeds
   - acorn
   - other seeds or leaves by name
   - dandelion leaf, flower, or fruit
   - plantain leaf, flower, or fruit
   - ant
   - cricket
   - sow bug
   - worm
   - caterpillar
   - unusual natural object
   - ant hill
   - worm casting

Instructional Objective	Concepts
Given appropriate materials, develop cultures of living organisms.	Organism Culture

Learning activity:

Encourage students to collect materials and containers for keeping and caring for live organisms. These organisms may be used for many activities throughout the unit. Let students prepare the plant and animal cultures themselves.

Emphasize Career Motivation objectives in this activity. As students work in groups to accomplish tasks, let them assume roles of leaders, co-workers, and followers. Involve students with various work processes such as procuring supplies, assembling equipment, making decisions, and evaluating results. Make students responsible for the survival and care of the organisms.

Below are suggested instructions for preparing habitats and cultures of many interesting organisms.

Terraria

Materials needed:

glass or plastic containers such as jars, boxes, aquaria
soil (may also include sand, vermiculite, or peat moss)
charcoal
rocks
dead leaves, rotting wood
suggested organisms: moss, grass seeds, clover seeds, weeds, cacti, earthworms, mealworms, salamanders

Instructions:

Choose an appropriate container in which to build the terrarium. Jars may be stood upright or placed on their sides. Prepare a thin layer of crushed charcoal on the bottom of the container. Add soil or a mixture of soil, sand, vermiculite, and peat moss. Plant small plants, sow seeds according to the type of habitat desired. Use a cover on the terrarium if high moisture content is to be maintained. Leave cover off for a desert terrarium.

Aquaria

Materials needed:

fish (goldfish, guppies, or other tropical fish)
snails
water
sand

Materials needed: (continued)

- plants
- plastic or glass aquaria or other suitable container, such as plastic shoe boxes or plastic meat trays
- fish food
- fish net
- heated aquarium

Instructions:

Students should be able to set up an aquarium with little or no instructions. It is important that the water be free of chlorine; therefore, it should stand for 24 hours before being used. Stirring or pouring also helps rid the water of chlorine. Students may use small aquaria during the week, but should transfer the fish to a heated aquarium over cold weekends.

Microorganisms

Materials needed:

- pond water
- dried grass or hay
- containers
- microprojector
- chlorine bleach
- microscopes

Instructions:

Collect water from a pond, lake, or stream. Place dried grass in a container of water and allow it to stand for two to four weeks. When a bad odor develops, cover the container loosely with a lid or some other suitable object.

Using a microscope or projecting microscope, observe drops of water daily. Take samples from the top, middle, and bottom of the container. Students can identify organisms by comparing what they see with pictures in reference books. Containers should be disinfected with a mild solution of chlorine bleach after the experiment.

Algae

Materials needed:

- containers
- light source

Instructions:

Many varieties of algae may be collected from ponds, lakes, streams, and tree trunks. Algae will grow faster in light. If the water contains organisms that feed on algae, a piece of white tissue paper will provide cellulose on which the algae will grow.

Green Plants

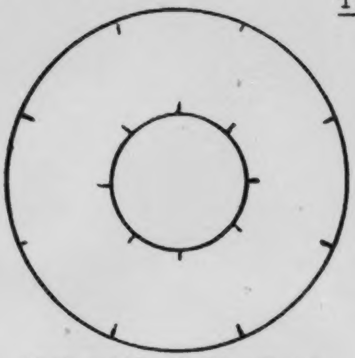
Materials needed:

seeds, such as beans, peas, pumpkin, grass, cloves, radishes
containers, such as milk cartons
soil, sand, vermiculite, peat moss

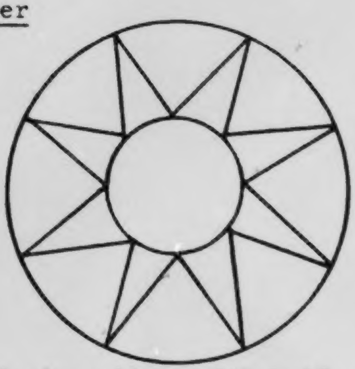
Instructions:

Let each student plant seeds in small containers or in a planter of some type. If space is available, old plastic wading pools or automobile tires turned inside out make good, large planters. Directions for making a tire planter are shown below.

Tire Planter

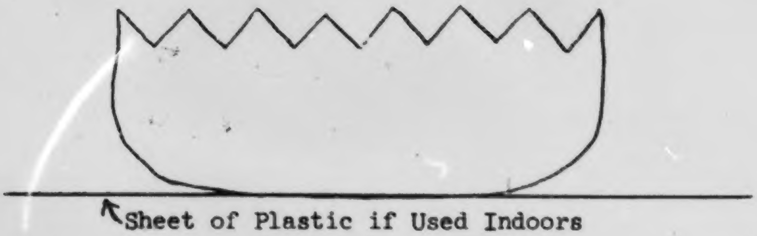


Mark with chalk about every 10 cm



Cut along lines with knife.

Turn inside out, paint, and fill with soil. Place metal wheel inside if available.



Sheet of Plastic if Used Indoors

Yeast

Materials needed:

dry yeast or baker's yeast
sugar
water
containers
litmus

Instructions:

Place yeast in a container of water. Add sugar. Observe changes in odor. Place a drop on a slide and observe with a microscope. Observe cells over a 15 to 30 minute period. See how long the yeast culture can live. Ask, "How can you tell the yeast is alive?" Test water with litmus paper or other acid-base indicator.

Mold

Materials needed:

bread
fruit
plastic bags
thumb tacks
chlorine bleach

Instructions:

Place moist bread, fruit, or other organic materials in plastic bags. Fasten each bag to the bulletin board. Observe the changes that occur over a period of days. Some molds cause sickness; therefore, do not permit students to open bags. Throw them away when finished.

Insects

Materials needed:

insects, such as beetles, ants, butterflies, moths
jars
wire or nylon screening
reference materials

Instructions:

Collect ants, beetle larvae, butterfly and moth larvae. Place them in a container suitable for observation. Provide food, such as sugar, bread, or leaves, as the case may be. Let students look up the organism in a reference book to find appropriate food.

Instructional Objective

Given an area outdoors, count and make a record of the organisms observed in it.

Concepts

Organism
Habitat

Materials needed:

paper, pencils, and other general supplies

Learning activities:

1. Have students draw a map of the school grounds or other area. This will help identify different places where organisms live. Use the word "habitat" in referring to places where organisms live.

2. Take students outdoors. Assign an area one meter square to each group of three children. Have them count the different kinds of organisms they can find. Keep a class record of the various kinds of organisms found around the school and at home. Use wise judgment in dealing with organisms that are pests in the home, such as termites, rats, and roaches.

3. Take a field trip to the community to observe and record the variety of plants and animal life there. Also visit a park, playground, one of the outdoor education centers in Cincinnati (LaBoiteaux Woods, Avon Woods, California Preserve), the Cincinnati Nature Center, Krohn Conservatory, or the Cincinnati Zoo.

# When planning the excursion to one of the community facilities, discuss with students the importance of the facility to the community. Also note the number of people and types of occupations needed to operate the facility. Discuss the value of such facilities to the community, how they are obtained, financed, and developed.

Instructional Objective

Given organisms, describe them by their properties

Concepts

Characteristic
Structure
Behavior
Adaptation

Materials needed:

organisms
pictures of organisms
cards containing pictures or names of familiar organisms

Learning activities:

1. Have individual students describe a specific organism. This may be done orally or in writing; in small groups or with the entire class. It may be done in the format of a game like

charades. One student will draw a card containing the name or a picture of an organism and will describe the organism by its properties. Others will guess the name of the organism.

2. Introduce the words "structure," "behavior," and "adaptation." Discuss their meanings as they apply to organisms and their properties. Have students classify a given list of characteristics as structural or behavioral.

Structural Characteristics	Behavioral Characteristics
size	how it moves
color	how it eats
shape	how it breathes
body parts	how it protects itself
body covering	how and where it builds its home
skeletal structure	
the number of legs	

3. Have students describe the similarities and differences of two given organisms. For example, compare (1) a particular plant with a particular animal, (2) one plant with another plant, (3) one animal with another animal. By choosing the organisms carefully, students will make interesting discoveries about the structure and behavior of organisms.

Instructional Objective

Given living organisms and non-living objects, name the properties which distinguish the living from non-living.

Concepts

Plants
Animals
Living
Environment
Survival
Organic
Inorganic

Materials needed:

object collection which includes the following:

- paper
- straw
- nail
- marble
- wood
- leather
- leaf
- potted plant

mealworm, fish (and/or other animals)
carrot, sweet potato, or other vegetables
apple
reference materials, such as books, filmstrips, and other media
pencils and paper

Learning activities:

1. Let students observe organisms over a period of time. Ask them to identify ways that living organisms are different from non-living objects. Illustrate these differences on charts and murals.

2. Provide groups of students with collections of objects, pictures, or a list of objects. Include some that are living. Ask students to identify changes that would occur in each object if it were subjected to the conditions listed below.

Condition	Changes
In Air - 20-30° C, 70-85° F	
In Water - 30-10° C, 0-50° F	
In Water over 40° C, 100° F	
In Air over 40° C, 100° F	
No Food	
No Oxygen	
Under Heavy Pressure	

Ask, "Which objects would change the least?" "Which objects must have a particular set of conditions to remain the same?"

Introduce the words "environment" and "survival." Have students find the definitions of "environment" and "survival" in a dictionary or other source. Ask which of the objects given depend upon their environment for their survival.

3. Provide students with a collection of objects and/or pictures of objects. Have them sort them into two groups: those that are living and those that are non-living. Have them tell why they think a particular object is living or non-living.

   Include parts of living things and have them classify the objects as organisms, parts of organisms, or non-living objects.

4. Ask students to classify objects into two groups: those that may have been part of a living organism and those that have not. Ask them to give reasons for including a given object in a specific category.

   Introduce the words "organic" and "inorganic." Discuss different definitions they might find. Let the class decide on the definitions they will use to classify objects as organic and inorganic. Let the students refine their previous classification by listing objects under the headings of organic and inorganic.

Instructional Objective	Concepts
Given an organism, name its parts and describe them.	Structure Cell

Materials needed:

- organisms
- pictures of organisms
- paper, pencil, and other art supplies
- reference books and other media
- flat toothpicks

Learning activities:

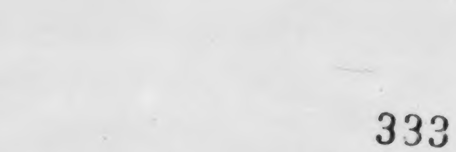
1. Provide students with a set of organisms or pictures of organisms. Let them identify all the parts they can. Have them draw one or more organisms and name the parts. Provide students with duplicated diagrams which students can label. Encourage students to use reference sources. The activity may be limited to external parts only, or some children may wish to include internal parts.

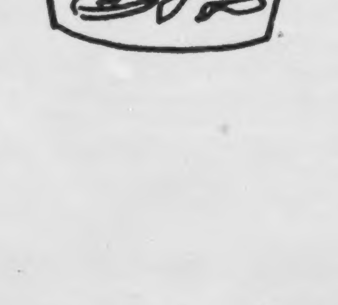
   Use a variety of plants and animals to familiarize students with the variety of structures that plants and animals have that may serve the same purpose.

   Some organisms that may be used are:
   - a tree
   - a flower
   - an insect
   - a worm
   - a bird
   - a fish
   - an amphibian
   - a reptile
   - a mammal

2. As students observe organisms, distribute hand lenses. As they look more closely at the surface of parts of organisms, they will observe details of the eye structure, the skin, or other body surfaces, mouth parts, and the like.

3. Vascular bundles of plant stems (the tubes that carry water and food) may be observed with a microscope if a thin enough slice can be made. Slice a potato lengthwise as though you were going to make french fries. Split the slice in half to about one-half its length. Cut grooves in the interior of each half. Insert the stem of a plant into the groove. Coleus or similar soft stem house plants are excellent for this purpose. Using a single edge razor blade make a number of thin cross section slices. Drop the potato pieces and stems into a tumbler of water. The potato pieces will sink but the stem slices will float to the surface. Select only the thinnest slices for a microscope slide. A cover slide should prevent fast drying out on a microprojector and facilitate viewing one on a microscope.





4. Let students view a piece of onion skin with a microscope or microprojector. If they do not yet know the word "cell," introduce it and discuss it. Refer to the animals and plants they have seen that have only one cell. Have them scrape the inside of their cheeks with a toothpick, and look at the scrapings with a microscope. Let them see if they can find cells. Dye the cells with iodine to make them more visible.

   Let them identify the similarities and differences between cheek cells and onion-skin cells.

5. As an optional activity, have students dissect organisms, observe and label their internal parts. Some organisms that are easily obtained and are easy for students to work with are: celery, onion, coleus, seeds (soak in water first), roots, and earthworms (preserved in alcohol).

   Plants may be dissected with fingers. This requires no special instructions. Students may explore plant parts freely. The cutting of plants or animals requires sharp instruments such as knives or single edged razor blades. Specific instructions and careful supervision is required in this activity. Fasten the organism to a piece of cardboard with pins. To avoid injury do not permit students to hold the organism with their fingers while cutting.

Instructional Objective

Given a collection of organisms, or pictures of organisms, classify them by observable characteristics.

Concepts

Classification
Plant
Animal
Diversity

Materials needed:

living organisms
pictures of living organisms
reference material

Learning activities:

1. Provide students with the materials listed above. Ask them to classify the organisms into two groups by an observable property. Do not force a standard classification on students at this time. Accept students' classifications.

2. Introduce the concept of diversity. Have students make a mural illustrating the diversity of forms of living things.

3. During a brainstorming session, ask students to name types of plants and animals they know. They may name such plants as trees, vegetables, flowers, fungi, and the like; and animals such as fish, reptiles, mammals, insects, spiders, and the like.

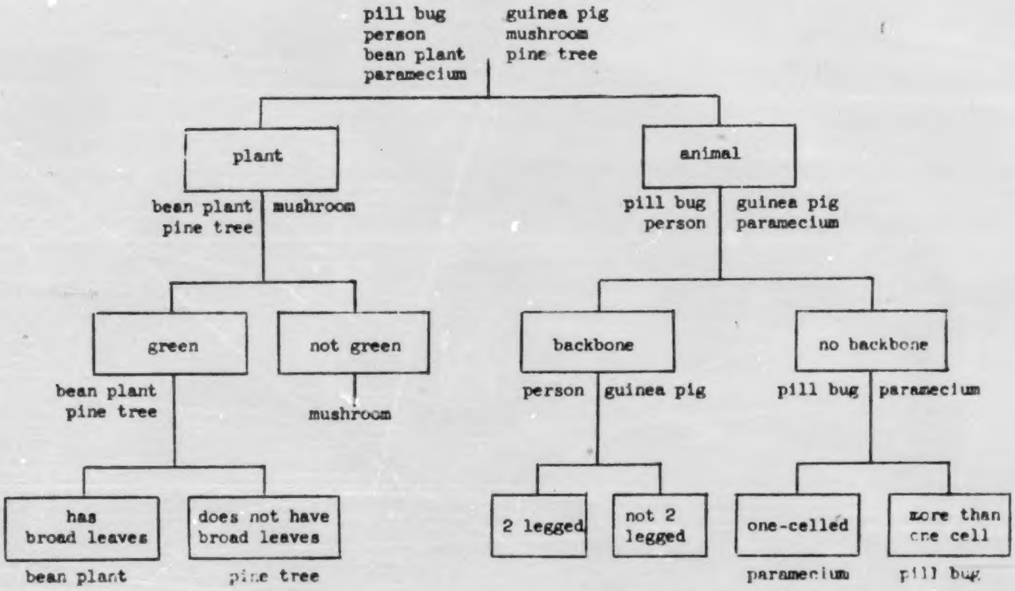
Provide them with real plants and animals or pictures of these. Have students name the identifying properties of each group. Do not tell students the properties and ask them to memorize them.

4. Remove the meat from a cooked chicken neck. Place the neck in a pan. Just cover with water; add 10 to 20 ml of vinegar. Boil for 10 minutes. Remove meat with tweezers and dry the neck on paper towels.

   Let students observe the vertebrae and describe its construction. Students may wish to bring in fish vertebrae to compare with the chicken neck. They may also study pictures of vertebrae of other animals and note similarities and differences.

5. Provide students with a list of organisms and have them place each name in an appropriate classification.

   One way students may classify organisms is by developing flow charts. One is illustrated below:


pill bug
person
bean plant
paramecium
guinea pig
mushroom
pine tree
plant
animal
bean plant
pine tree
mushroom
pill bug
person
guinea pig
paramecium
green
not green
backbone
no backbone
bean plant
pine tree
mushroom
person
guinea pig
pill bug
paramecium
has broad leaves
does not have broad leaves
2 legged
not 2 legged
one-celled
more than one cell
bean plant
pine tree
paramecium
pill bug

6. Some able pupils may wish to investigate the classification system used by biologists. This may be done individually or in a small group.

Instructional Objective

Given a collection of organic materials, (1) name the organisms from which the materials come, (2) identify other objects made from a given material, and (3) name occupations that use the given materials.

Concepts

Organisms
Materials
Occupations

Materials needed:

a collection of objects made of organic materials (pictures of objects or a list of objects may also be used) including leather, wood, paper, alcohol and rubber

Learning activities:

1. Have students list many objects made of organic materials. Encourage them to collect these objects or pictures of them. Individuals or groups may prepare collections and have classmates name the organism from which the object came.

2. Provide students with a collection of objects. Have students name the materials from which the objects are made. Ask them to list or name other objects made of each material.

# 3. Ask students to identify occupations in which people use the organic materials listed above.

As a variation, the teacher may give the students the name of an occupation and have them list the organic materials people in that occupation would use.

Instructional Objective

Given experience with organisms, identify patterns in organisms and their habitats.

Concept

Pattern

Materials needed:

terraria and aquaria
access to the outdoors
reference books, pictures and other media
art supplies

Learning activity:

Have students look for patterns in organisms in the classroom or outdoors. Ask students to draw pictures or make displays that show patterns of shape, arrangement, or repetition. Leaves, seeds, roots, tree bark, tree shapes, butterly wings, grass, fruit cut open, life cycles of organisms, and seasonal changes are examples that students can observe and identify.

Instructional Objective	Concept
Given organisms in a habitat, identify and record changes that occur in the habitat and in the organisms.	Change

Materials needed:

terraria and aquaria
access to the outdoors
reference books, filmstrips, and other media

Learning activity:

Have students record observations of organisms and their habitats over a period of time. This may be done from real life or with media such as filmstrips, study prints, or films. Ask students to name changes that occur such as growth, development of structure, death, seasonal change, and weather changes. Define the word "change."

Let students suggest examples of change; draw pictures or write stories of changes in organisms.

Instructional Objective	Concept
Given reference sources, have students prepare a report on, make a chart of, or dramatize occupations that involve living organisms.	Occupations

Materials needed:

reference sources
art supplies
costumes and/or stage props

Learning activity:

# Have students brainstorm or locate in reference sources the names of occupations that involve plants or animals, such as veterinary medicine, horticulture, grooming and training, meat industry, food packaging, and the like. Let small groups of students make oral reports, draw pictures, make murals or a bulletin board display depicting these occupations. Some students may wish to develop skits for other students to guess the occupation depicted.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

1434	Deer and Its Relatives, The
1990	Fish Are Interesting
1864	Five Colorful Birds
169	Life Story of the Paramecium
1986	Mammals Are Interesting
1910	Microscopic Wonders in Water
1992	Reptiles are Interesting
1448	Snakes Are Interesting
2193	Spiders (2nd Edition)
60	What's Alive

Filmstrips

7281-85	Animals Without Backbones
6144	Bears, Pandas, and Raccoons
6142	Cats and Dogs
7193	Discovering Mammals
7316	Finding Living Things (Learning About Living Things)
6140	Large Hoofed Mammals
7317	Living Things Hard to See (Learning About Living Things)
6149	Lizards of the World
7229	Plants are Living Things
6143	Primates, Monkeys and Their Relatives
6501	Seed Plants
7283	Snail and Its Relatives, The
6145	Snakes Outside of the U.S.
6914	Water Life--Fresh Water Shellfish and Amphibians
6913	Water Life--Small Fresh Water Animals and Insects
7315	What Is Alive (Learning About Living Things)

Recordings

9406	Plants and Animals

Mounted Pictures

10245	Common Birds
10244	Common Insects
10239	Reptiles and Amphibians
10243	Broadleaf Trees

A-V Media Approved for Purchase

Filmstrips

Encyclopaedia Britannica Educational Corporation

Learning About Living Things

What Is Alive?
Finding Living Things

Animals Without Backbones

One-Celled Animals
Different Kinds of Worms
Lobster and Its Relatives
The Sea Star and Related Spiny-Skinned Animals
The Snail and Its Relatives

Encyclopaedia Britannica Educational Corporation (Continued)

Animals With Backbones

Discovering Amphibians
Discovering Birds
Discovering Fishes
Discovering Mammals
Discovering Reptiles
Observing Birds in Nature
What is a Vertebrate?

INVESTIGATING LIFE

Background

Life Needs. Living organisms need food, air, water, and protection. Food provides the energy and the materials needed for growth and repair. Air is required in the process of respiration in which plants and animals use oxygen to burn food and give off carbon dioxide. Green plants use the carbon dioxide in the air to manufacture food. Water dissolves minerals and other food materials and furnishes the fluid that carries food and waste materials through organisms. Plants and animals need protection from enemies, excessive heat, drought, and other unfavorable environmental conditions.

Life Processes. All organisms have life processes that enable them to exchange the materials and energy they need to sustain life. The life processes presented in this unit are respiration, food getting, mobility, and response to stimuli. The processes of growth and reproduction are dealt with in the unit *Continuation of Life*.

Adaptations. Organisms have body structures and habits of behavior that enable them to carry out life processes to meet life needs. These are called adaptations. Organisms have adaptations suitable for meeting their needs in a given environment. Some organisms are adapted to live in very specific environments, others are adapted to live in a wide variety of environments.

Mammals, birds, and reptiles, for example, have lungs which enable them to extract oxygen from the air. Insects have spiracles in their sides which enable them to do the same thing. Fish have gills which enable them to extract oxygen from water.

Animals have adaptations for obtaining food, such as a keen sense of smell, hearing, and seeing. They also have claws, teeth, beaks, and overall body structures that enable them to eat the specific food they need.

Green plants have roots that can absorb water and minerals, leaves that have stoma for taking in air, chlorophyl for making food, vascular bundles for transporting fluids, cellulose stems for support.

Mushrooms have mycelium which anchor them and help them obtain food from decaying plant and animal matter.

Plants and animals have structures which help them to protect themselves such as: weapons (claws, beaks, teeth); limbs for escaping danger (legs for running; fins, flippers, and feet for swimming; wings for flying; and claws for digging).

Plants and animals have adaptations for seasonal change such as: trees losing leaves; plants producing seeds; animals hibernating, migrating, and estivating; and animals changing color of fur for winter and summer.

Environment. The requirements of organisms are supplied by the environment. The environment includes all the factors, both materials and conditions, that affect and support life. Environmental factors may be favorable or unfavorable to the needs of organisms. Environmental factors vary from place to place; therefore, there are many different kinds of environments. Environmental factors change throughout the year and over longer periods of time.

There are, therefore, many kinds of interrelationships within a given environment. Conditions of climate affect the temperature, humidity, water supply, and food supply. Although one species may be able to live in a particular climate, the species it feeds upon may not. The size and even the existence of a given population depend upon a number of interrelated factors. The presence or absence of a single factor may upset the balance and cause a species to move to another location or to become extinct.

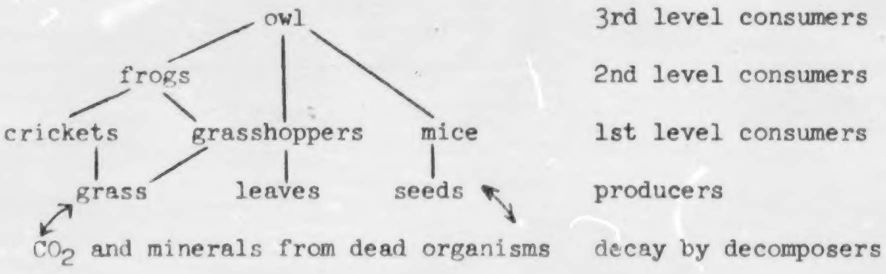
Habitat. Plants and animals live in specific kinds of places called habitats. One can speak of a pond habitat, a meadow habitat, a forest habitat, and the like. One can also think of the species of organisms that live in a habitat as communities, such as a pond community, a meadow community, or a forest community. The living and non-living factors make up the environment. All of these together make up ecosystems. There are also large regions of relatively uniform climates called biomes.

Interdependence. Organisms both affect and are affected by their environment. Organisms also affect and are affected by one another. The relationships between organisms and their environments and the relationships among organisms are interdependent. Each organism contributes something and receives something.

Each organism has a specific role or "niche" in the community. For example, each organism may be classified as a producer, a consumer, or a decomposer. Producers are the green plants in the community. Green plants manufacture food. Consumers are the non-green plants and animals that feed on green plants. Decomposers change organic material back into carbon dioxide and minerals which can be used by green plants to make food.

Consumers may be first level--organisms that get food from plants, second level--organisms that feed on first level consumers, and third level--animals that feed on second level consumers.

Models which illustrate this type of role are the food chain and food web. An example of a food chain would be: a cricket eats grass; a frog eats crickets, and an owl eats the frog. Food chains can be put together to form food webs.



An environment ,then ,is a life support system, a self-sustaining ecosystem. A system, in order to be life-giving, must provide for the exchange of materials and energy. Materials and energy must be recycled and reused over and over. The sun provides energy which empowers ecosystems and maintains them.

One can easily see that the food needed to support one owl would include not only a large number of second level consumers but also an even larger number of first level consumers, and a tremendous number of producers.

The niche of a scavenger, such as snails, crayfish, vultures, and the like, is to help keep the environment clean by feeding on dead and decaying organisms.

The decomposers, such as bacteria, yeasts, and molds, cause dead organisms to decay. Decayed organisms return minerals to the soil and nitrogen and other gases to the air. Decaying plant and animal matter is frequently used as fertilizer.

Some special relationships that exist between two species of organisms are as follows:

saprophytism - non-green plants feeding on dead organic matter

symbiosis - organisms of two species living together

parasitism - one organism feeding on another living organism without immediately killing it (roundworms, hackworms, ticks, lice, mosquitoes, leeches, and mistletoe)

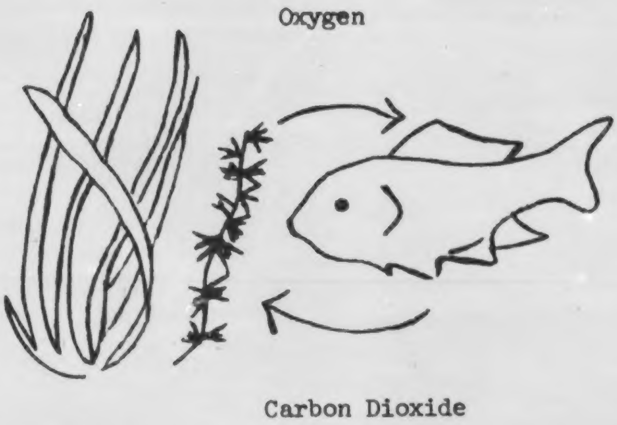
commensalism - one organism living on another organism without harming it, but eating the crumbs left by the host.

mutualism - two organisms living together for the mutual benefit of both (aphids and ants, livestock and man, birds and rhinoceroses, and algae and fungi that form lichens)

Cycles - The foregoing included a description of a food cycle. It is complex, but the materials go from one organism to another until decay produces more carbon dioxide and minerals for the plants. Other cycles that are in effect in a community are the oxygen-carbon dioxide cycle, the nutrient cycle, the energy cycle, the water cycle, and life cycles of organisms.

Unless disturbed by some limiting factor, such as a change in climate or interference by man, these cycles continue. The sun continues to provide energy which keeps the cycles going. If the balance is disturbed, a new equilibrium is usually established.

The Oxygen-Carbon Dioxide Cycle



The Nutrient Cycle

Carbon dioxide in air

Green plants manufacture food by photosynthesis

Animals eat food

Animals produce CO_2 when they breathe and when they decay

The Energy Cycle (An Incomplete Cycle)

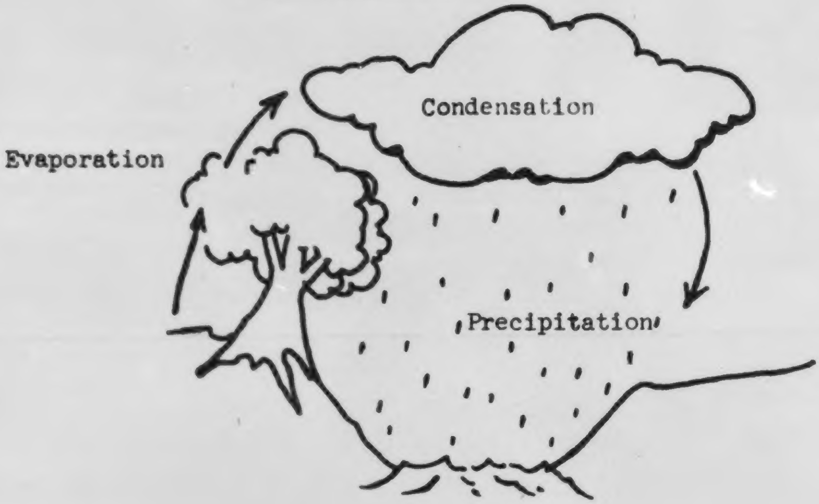
The sun provides energy

Green plants use the energy to manufacture food

Animals get energy from food stored in green plants

Energy is transferred to other animals or stored in earth as coal, oil, and gas

The Water Cycle



Man's Role in the Environment. Man has played a unique roll in the environment. Man, through his inventiveness has been able to overcome his natural enemies, extract natural resources, use many materials of the earth for his benefit, cultivate crops for food and clothing, increase the production and quality of plants and animals, and in many other ways has dominated life on earth.

Problems of pollution, over population, starvation, food and energy shortages, and endangered species have made it apparent that man has not always acted wisely in his use of the environment. These problems also indicate the absolute necessity that man deal responsibly with the environment, now and in the future. Man's efforts to produce material goods to supply his needs has often interfered with the natural cycles.

Governments, scientists, special interest groups, and individuals have made efforts to protect and improve the environment through legislation and other community actions. These efforts have included conserving natural resources, recycling materials, population control, and pollution control.

Rationale

The unit, Investigating Life, is designed to help students (1) identify, observe, and describe the life needs of plants and animals, (2) investigate the life processes and adaptations of organisms that enable them to meet life needs, (3) investigate the environmental factors that contribute to the lives of organisms, (4) identify and describe the interdependence of living things with each other and with their environment, and (5) identify man's role in the environment.

The kind of problems associated with the ecological situations presented in the unit should help students develop values based on their understanding of the contribution of each organism. The information and experiences provided should help students gain insights into their relationship with their environment.

Glossary of Concepts

Habitat	A place where organisms live.
Environment	The combination of all external factors that enable an organism to live and carry out its life processes.
Environmental Factor	Any part of the environment that affects the life of organisms.
Life Needs	Objects or conditions that are essential to the life of a plant or animal.
Life Processes	The functions that organisms perform in order to satisfy life needs.
Respiration	The process of taking in air, using oxygen, and giving off carbon dioxide.
Mobility	The movement of an organism from one place to another.
Population	All the individuals or organisms of a particular kind.
Community	All the plants and animals that live in the same area and depend upon one another for food and other life requirements.
Ecosystem	A unit consisting of a community interacting with its physical environment.
Osmosis	The process by which fluids pass through membranes; the process by which plants take in water and the minerals that are dissolved in them.
Capillary Attraction	The attraction between solids and liquids that enables liquids to move through plants.
Photosynthesis	The process by which green plants manufacture food from water and carbon dioxide using light as the energy source.
Warm Blooded	Having constant body temperature usually higher than surrounding air or water; body temperature internally controlled.
Cold Blooded	Having body temperature close to that of the surrounding air and water.
Adaptations	Structures and behaviors that enable an organism to carry out life processes.

Structure	The arrangement of parts of an organism.
Behavior	Action or reaction in relation to the environment.
Extinct	Species no longer living; lacking survivors.
Home	The specific place or abode where an organism lives, such as a nest, a cave, or a house.
Food Chain	A pattern of interrelationships of food sources; transfer of food from plants to plant eater to animal eater.
Food Web	A combination of two or more food chains that support a single animal eater.
Producer	An organism that makes its own food. The green plants in a community.
Consumer	Any organism that feeds on another organism.
Decomposer	The organisms in a community that change organic matter into materials that producers can use to make food (usually bacteria, molds, and yeasts).
Cycle	A repeating or recurring pattern of events.
Niche	The role of a plant or animal species in a community.
Predator	An animal that kills and eats other animals.
Prey	An animal that is killed and eaten by other animals.
Pollution	The presence of impurities in water, air, or soil.
Recycling	Using materials that have been used previously.
Conservation	Prevention of materials from being used up, polluted, or lost.

Investigations

Instructional Objective	Concept
Given appropriate material, construct terraria and aquaria that illustrate specific habitats.	Habitat

Materials needed:

Terraria
- glass or clear plastic containers
- soil
- sand
- charcoal
- living organisms (moss, grass, and clover seeds, rotting wood, weeds and other plants found outdoors, cacti, mealworms, earthworms, pill bugs, salamanders, crickets, cameleons, toads, frogs)

Aquaria
- glass or clear plastic containers
- sand
- water
- fish
- plants
- snails

Learning activities:

# Provide materials or plan a field trip to collect specimens for terraria. If such a field trip is planned, obtain permission to collect specimens from the owner of the property. Parks and other public areas have stringent rules against collecting specimens.

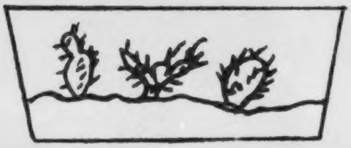
Introduce the word "habitat." Define it as a place where organisms live.

Let students build aquaria and terraria typical of specific habitats, such as pond, tropical stream, desert, woods, and field. Aquaria and terraria may also be designed to provide a habitat for specific animals, such as tadpoles, frogs, tropical fish, ants, mealworms, crickets, and cameleons. The teacher may provide specific instruction or may make this a relatively non-directive activity. Students may refer to reference books and other media. If large numbers of students are using the materials, students may dismantle the aquaria and terraria after one or two class periods so that others may use the materials.

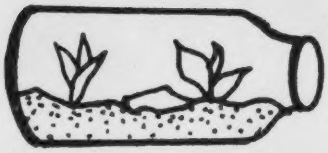
Encourage students to construct terraria and aquaria at home and report the progress of their project to the class.

Career motivation activities should be emphasized as students work together. They will assume roles of leaders, followers, and co-workers. They may be involved with various work processes, such as procuring supplies, assembling equipment, making decisions, and evaluating results. They also will have responsibility for the survival and care of the organisms.

Cacti,
Sandy Soil



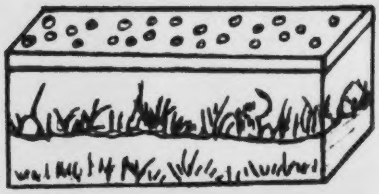
Desert Terrarium



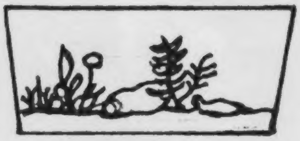
Houseplant Terrarium

Houseplants,
Soil,
Decorative Rock

Perforated Lid,
Grass and Clover,
Crickets,
Soil and Sand,
Charcoal



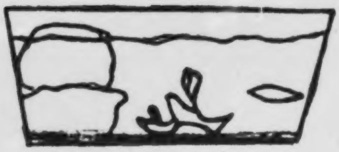
Field Terrarium



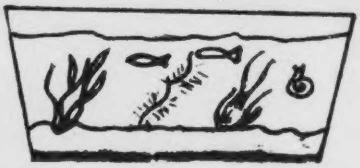
Woods Terrarium

Piece of Wood or
Rotting Log,
Sod, Weeds, Moss,
Pillbugs, Mealworms,
Salamanders

Algae,
Pond water,
Tadpoles,
Crawfish



Pond Aquarium



Tropical Aquarium

Water,
Sand,
Plants,
Fish, Snails

Plan a trip around school, the school neighborhood, a park, or an outdoor education center. Have students identify the kinds of places where organisms live. They may suggest such places as houses, apartment buildings, a field, a forest, a tree, a pond, a rotting log, and a hole in the ground. Let students hunt for organisms and identify the places where they found them. Have students record organisms and their habitats on a data sheet.

organism	habitat
grass	field
ant	field
shelf fungus	rotting log
termites	rotting log
man	house

Ask, "What other habitats can you name? What organisms live in a pond? a desert? a forest? the tundra?"

Encourage students to use reference materials to find information about various habitats. Let them make dioramas to show organisms in specific habitats.

Instructional Objective	Concepts
Given appropriate materials, describe plant and animal habitats.	Environment Environmental factor

Materials needed:

aquaria and terraria
outdoor sites
pictures, books, and other media
thermometers

Learning activities:

# 1. Give students the opportunity to describe habitats of many kinds, including habitats of man. Provide a variety of terraria and aquaria, outdoor sites, and pictures of habitats. Descriptions may be oral, in writing, or illustrated with drawings.

2. Introduce the terms "environment" and "environmental factor." Define them and discuss the definitions with the students. Ask, "What environmental factors are in the room or other setting?"

3. The students' descriptions will include many objects and conditions that affect organisms. Point out that these are environmental factors.

Habitat: Classroom
Environmental Factors:
temperature - 72° F, C
objects - desks, chairs, paper, supplies, flag, bulletin boards, terraria, aquaria, air
organisms - people, flies, gerbils, plants

Habitat: Woodland Terrarium
Environmental Factors:
temperature
relative humidity
objects
light
organisms

Habitat: The City
Environmental Factors:
- topography (natural features)
- climate
- organisms
- buildings and other structures
- business, industry, and transportation

Ask, "How do animals get air? What is the process of getting air called?" Introduce the term "respiration." Introduce "life processes." Introduce "mobility" and any other word related to life processes. Relate these processes to the life needs the students identify.

Instructional Objective

Given appropriate materials and outdoor sites, identify the life processes of organisms.

Concepts

- Life needs
- Life processes
- Respiration
- Mobility

Materials needed:

- terraria and aquaria
- chalk board
- chart paper
- natural habitats, outdoors

Learning activities:

1. After students have had experiences with organisms and their habitats, ask them to tell what organisms need in order to survive. Make a list of the needs and display it prominently in the room. Call attention to the different habitats identified previously and ask students to describe how each of the needs are met. Define "life needs." Ask students to describe how each of the needs are met within specific habitats.

# 2. Make a chart to compare life needs of specific organisms. What similarities and differences are noticed? How are man's needs different from other organisms? In what ways are man's needs the same as other organisms?

CAT	INSECT	WORM	PLANT	MAN

3. Ask, "How do animals get air?" or "What do we call the process of getting air?" Introduce the term "life processes." Use at least one example, such as breathing or food getting. Relate

these to the life needs identified. Have students name the processes by which the life needs are met.

Some examples are:

Need	Process
oxygen	breathing, respiration
food	food getting, eating
water	drinking
proper temperature	moving to warmer climate, growing fur or feathers
removal of waste	perspiration, elimination, transpiration, respiration
protection	moving, fighting, deception

Some life processes do not fit the chart above very well because the need they fill is not obvious or easily expressed. Ask students to name other life processes and name the needs they fulfill.

Some examples are:

Process	Need
movement	protection, obtain food and water, escape
respond to stimuli	protection
reproduction	survival of the species
hearing	protection
seeing	protection, get food, enjoyment
smelling	protection, get food

Instructional Objective	Concepts
Given a specific habitat, take a census of the population within it.	Population Community

Materials needed:

terraria and aquaria
outdoor sites
twine

Learning activities:

Have students list all the different kinds of organisms in a terrarium or aquarium. Have them count the number of organisms of each kind and record it on a chart.

Introduce the terms "population" and "community." Define them and use them throughout the unit.

Take students outdoors in a grassy area. Give them a piece of twine about one meter long. Have them tie the ends of the twine to form a circle. Have each student (or pair of students) take a census of each population within the circle. Include plants as well as animals.

Instructional Objective	Concept
Given a plant or animal culture, record and describe population growth.	Population

Materials needed:

plant or animal culture
graph paper

Learning activity:

Have pairs of students observe a given population and record its growth on a graph over a period of time. Put the graphs on a bulletin board and use them for future reference.

Instructional Objective	Concept
Given appropriate materials, construct a sealed ecosystem.	Ecosystem

Materials needed:

plastic bag
jars with lids
soil
plants
water
appropriate animals: snails, guppies, worms, isopods (pillbugs), ants, beetles, spiders

Learning activity:

Provide students with materials suggested above and let them try to construct a sealed habitat for some small animals and plants. Introduce the term "ecosystem." Explain that an ecosystem provides all the materials and conditions necessary for continuing life and that nothing needs to be added or removed. If plants and animals are in the right proportion, the organisms should survive for weeks, months, or even years.

Instructional Objective	Concept
Given appropriate materials, demonstrate how liquids pass through membranes in the process of osmosis.	Osmosis

Materials needed:

plastic bags (sandwich size)
gelatin, plain
string
plant roots
hand lenses
charts and other reference materials

Learning activities:

1. Pour a cup of hot water over plain gelatin, stir, and add a half cup of cold water. Pour about one-fourth cup of gelatin into a plastic bag. Prepare sufficient quantity so that students can work in pairs. Let students add one or more of the materials below to the gelatin solution. Tie the bag with a string so there is little or no air in the bag.

Materials to add to the gelatin	Indicator
starch	iodine
vinegar	blue litmus
baking soda	pink litmus
after shave lotion or cologne	smell

   Place the gelatin bag into a container of warm water. Let the mixture set for a few hours; then test the water with the appropriate indicator to see if any of the material in the bag moved through the plastic bag.

   Ask, "How did the material get into the water? How could this help explain how water and minerals get into plant roots?"

2. Introduce the concept of "osmosis." Have students look it up in dictionaries and encyclopedias.

3. Collect many different types of plants. Provide hand lenses and let students find the root hairs. Use classroom charts or other pictures that illustrate the cell structure of plant roots. Ask students to describe how plants are adapted to take in water and minerals.

Instructional Objective	Concept
Given appropriate materials, demonstrate capillary attraction and describe how water and minerals get into the leaves.	Capillary attraction

Materials needed:

celery
food coloring
water
glass or plastic tumbler
paper towel
cloth
blotter
glass tubing

Learning activities:

Let students explore the phenomena of capillary attraction with the following activities. CAUTION: The third activity is dangerous; exercise judgment in introducing this activity.

1. Cut the bottom off a celery stalk and place the top part, with the leaves, into a container of water. The water should be 3 to 5 cm deep. Place a few drops of red or blue food coloring into the water and stir. Let it set for several days and observe. Cut the stalk off above the water level and observe. Vascular bundles can be seen clearly in this way.

2. Place the tip of a paper towel, a piece of cloth, a piece of blotter, paper and/or filter paper into some water. Observe what happens to the water and the paper.

3. Heat the center of a piece of glass tubing (about 20 cm long) in a flame until it is soft, then pull gently but firmly, to form a long, thin tube. After it cools, use a file to cut the tubing into lengths approximately 30 cm long. Make tubes in this manner that vary in inside diameter. Dip the tips of the tubing into water colored with food dye. Ask, "What happens to the water? Which tube works the best? What variables affect the movement of the water the most?"

   Have students look up the term, "capillary attraction." Ask them to explain how this helps plants.

Instructional Objective	Concept
Given appropriate materials, illustrate the process of photosynthesis.	Photosynthesis

Materials needed:

bean plant (or other green plant
geranium
beaker (heat resistant)
grain alcohol
metal pan
water
electric hot plate
iodine

Learning activities:

1. Place a green plant in the dark and keep it there for several weeks. Keep another plant of the same type in the sunlight. Observe similarities and differences in color and growth.

2. Extract chlorophyl from a geranium leaf. The teacher should perform this demonstration because of the danger involved. Place the leaf in a beaker containing about 150-200 ml of grain alcohol. Place the beaker in a pan of water and heat to boiling on an electric hot plate. Observe the color of the leaf and the color of the alcohol. Test the leaf for starch by placing a few drops of tincture of iodine on it.

3. Have students draw pictures of green plants showing the parts of the plant and indicating how each part is adapted for doing its job in the process of photosynthesis.

Instructional Objective	Concepts
Given a clinical and an outdoor thermometer, demonstrate that man is warm blooded.	Warm blooded Cold blooded

Materials needed:

oral thermometer
room or outdoor thermometer
reference materials

Learning activities:

1. Have students read the outdoor temperature and their own temperature for five days. A bar graph will show variations well. Ask, "What do you conclude about body temperature? If you recorded the temperature of other animals, such as dogs, cats, birds, fish, frogs, and snakes, would you get the same results? How could you find out if a frog's temperature is affected by the surrounding air or water?"

2. Develop the concepts of "warm blooded" and "cold blooded." Define the terms and let students find examples of each in reference materials. Ask, "How does being warm blooded or cold blooded enable an animal to adapt to his environment?"

Instructional Objective	Concepts
Given specific organisms, identify ways they are adapted to meet their life needs in their environment.	Adaptation Structure Behavior

Materials needed:

living organisms
pictures of organisms

Learning activities:

1. Have students observe living organisms, or pictures, models, and preserved specimens. Ask them to name ways the organism is adapted to its environment. Ask, "How is this animal adapted to move, to obtain food, to eat its food, to keep warm, to breathe, to protect itself?" or "How does this plant obtain water and minerals? How does it make food? How does this plant protect itself?"

2. Show students a variety of animals and ask such questions as: "What does each animal eat? How is each animal adapted to

obtain food? How do its feet help it? its teeth? its size? its mouth?

3. Have students study different kinds of animals, such as birds, mammals, fish, and the like. Ask them to describe the beaks, feet, legs, and body of different kinds of birds and tell how each animal adapted to obtain and eat its food.

4. Have students study different kinds of plants. Ask, "How do plants protect themselves from animals? How are they adapted to the changes in temperature throughout the seasons? How are some plants adapted to live in the desert? How are plants adapted to obtain water?"

# 5. Have students observe an animal over a period of time and record the time it spends in various activities. Show films and other media to provide additional information. Ask, "What type of work do animals engage in?" Some suggested answers may be food getting, food storing, infant care, transporting objects, home building, and defense training. Some good animals to observe are ants,gerbils, fish, fruit flies, and other insects, dogs, and cats. Information about larger animals may be obtained from films.

6. Introduce the concepts "structure" and "behavior." Define the terms. Have students identify examples of structural and behavioral adaptations.

Instructional Objective	Concepts
Given pictures or specimens of animals, classify them by behaviors and indicate the adaptation which gives evidence for the classification.	Adaptation Behavior

Materials needed:

pictures of mammals (specimens if available)
reference material

Learning activities:

# 1. Provide students with pictures (or specimens) of mammals, including man. Have them classify mammals into one or more of the following categories of behavior: (1) insect eaters, (2) meat eaters, (3) handlers, (4) grazers, (5) gnawers, (6) fliers, (7) swimmers. Have students indicate the adaptations which give evidence for the classification. A mammal may be placed in more than one category. If the teacher wishes, let students use reference books to support their ideas.

The following chart may be helpful:

MAMMAL	BEHAVIORAL CATEGORY	ADAPTATION
Mouse	gnawer	long front teeth

2. Use the activity above with other kinds of animals, such as birds, fish, reptiles, or insects. Let students make up categories which apply to each kind of animal. Some suggestions are given below:

Birds - predators, seed eaters, insect eaters, fish eaters, scavengers, waders, divers, swimmers, and the like

Reptiles - runners, swimmers, crawlers, poisoners, constructors

Fish - scavengers, predators, bottom feeders, top feeders, salt water, fresh water

Insects - fliers, crawlers, borers, plant eaters, meat eaters.

3. As an alternative, have students observe a particular animal or picture of an animal and infer as much as he can about its behavior by studying its physical characteristics. Questions that may be helpful are: "What do you think he eats? How does he get his food? How does he protect himself? How does he move? What evidence do you have to support your ideas?"

Instructional Objective	Concepts
Given a plant or animal, construct an environment that best meets its needs.	Adaptation Environment

Materials needed:

glass or plastic container
soil
sand
seeds
thermometer

Learning activity:

# Provide students with materials for making a small terrarium. Give each student either a plant or an animal that requires a specific kind of environment. Encourage students to construct terraria that meet the life needs of specific kinds of organisms.

With plants, encourage students to vary the type of soils, the temperature, the light, moisture, the number of plants, depth of planting and any other variable they might think of. Suggested plants are coleus, beans, cactus, or tomatoes.

With animals, encourage students to vary the moisture in the soil, the temperature, the light, the number of occupants.

Have students vary factors when working with plants and determine which ones are best suited for their organism. Some factors that students may wish to vary are:

For plants	For animals
size of container	size of container
type of soil	material in container
amount of heat	amount of light
amount of moisture	amount of heat
amount of light	amount of moisture
number of plants	number of organisms
distance apart	

Suggested organisms:

Plants	Animals
coleus	mealworms
cacti	pill bugs
beans	land snails
tomatoes	slugs
	cameleons

Some topics that students may wish to investigate are:

migration
hibernation
estivation
protective coloration
animal weapons
protective coverings
size
population size

Instructional Objective	Concepts
Given a variety of plants, describe similarities and differences of specific parts.	Plant adaptations Structure

Materials needed:

plants (carrots, coleus, clover, weeds of various kinds)
hand lenses

Learning activities:

1. Provide a variety of plants or ask students to bring in plants. Let students study the root systems and describe the similarities

and differences. Ask, "Where do you think these plants would grow best? How do you think the particular root structure helps each plant? Which have top roots? Which have fibrous roots?"

2. Have students observe leaves and stems of various plants and describe their similarities and differences.

Instructional Objective	Concept
Given the name of a specific animal, describe how it interacts with its environment to build its home.	Home

Materials needed:

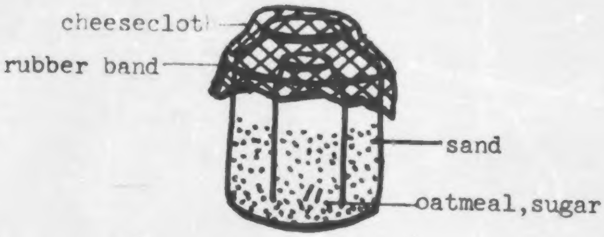
ant farm
ants
sugar
jars (small and large)
sand
oatmeal
cheese cloth
cardboard
cotton
rubber bands
bird nest
tweezers
hand lenses
newspaper
reference materials

Learning activities:

1. Place the oatmeal and sugar inside an ant farm. Observe and record observations. Ask students, "How many ants are in the colony? What food do they eat? Where do they build tunnels? Where do they build caves? How do they construct their home? What materials do they need in order to survive?"

   Observe ants outdoors. Where do they find their food and the materials from which to build their homes?

   If an ant farm is not available, construct one as follows. Place a small jar inside a large jar. Put sand between the two jars. Put the food materials and ants inside the inner jar. Place moist cotton on top of the sand, cover the outer jar with cheese cloth and secure with a rubber band.



2. Obtain a bird nest (not in use) and have students take it apart on a large sheet of newspaper. Separate the various materials into piles. List the materials and indicate the place from

which each part came. Ask, "How many different living things helped produce these materials? Which of the materials are inorganic?"

3. Give each student the name of an animal. Ask him to find information about how the animal builds his home and what materials it uses. Provide reference materials.

# 4. Have students list the materials in their homes. Ask, "From where did these materials come? What processes were used to produce these materials? What occupations were involved in producing and transporting these materials?"

Instructional Objective	Concepts
Given the names of extinct animals, describe them and their environment. Infer how they became extinct.	Adaptation Extinct

Materials needed:

list of extinct animals
reference materials

Learning activities:

1. Have students choose an extinct animal from a list provided and use reference materials to find information about the animal's adaptations, habits, and environments. Ask students to infer why the animals became extinct.

# 2. Let interested students write the following sources for information about present day endangered species.

The Wildlife Federation
1412 16th Street, N.W.
Washington, D.C. 20036

National Audubon Society
1150 Fifth Avenue
New York, N.Y. 10024

3. Have students use reference materials to identify plant and animal species that have survived the longest and identify the variables that have enabled them to do [illegible]. Have them investigate the adaptations of plants and animal species that seem almost indestructible. Some outstanding examples are crab grass, dandelions, cockroaches, ants, and rats.

# 4. Have students investigate organizations and occupations concerned about the survival of animals. They may also wish to investigate laws that protect animals. Plan field trips to see how various facilities are used to protect animals, such as the Zoo, Hueston Woods, and the Cincinnati Nature Center. Encourage students to watch programs on television related to endangered species.

Instructional Objective

Concepts

Given the names or pictures of plant and animal species, construct food chains and food webs.

Food chain
Food web

Materials needed:

- reference materials
- aquaria and terraria
- filing cards
- pictures of plants and animals

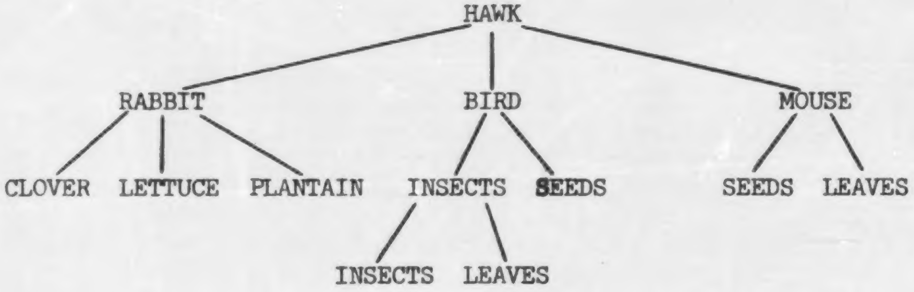
Learning activity:

Use the aquaria and terraria in the room to help students identify food chains. Place the following on file cards and ask students to observe a specific ecosystem and fill in the blanks.

__________eats__________eats__________

When filled in, these cards can be used to label a specific aquarium or terrarium.

Place the names of organisms on file cards. Let students work in small groups to construct food webs similar to the one below.



Instructional Objective

Concepts

Given a specific plant and animal community, classify the living organisms as producers, consumers, and decomposers.

Producer
Consumer
Decomposer

Materials needed:

- terraria and aquaria
- pictures of plant and animal communities
- field experiences
- rotting plant and animal matter

Learning activities:

1. Have students observe terraria and aquaria and pictures of plant and animal communities. Have them use reference materials to define "producer," "consumer," and "decomposer." Discuss these terms. Decomposers, such as fungi, molds, and lichens, can be observed directly, but microscopic organisms, such as bacteria, may not. Identifying evidence of decomposition requires experience. Samples of rotting animal material in closed containers should be displayed as reference. Be very cautious about having students smell these.

2. Plan a trip around the community, to a field, a vacant lot, a wooded area, or by a pond. Have students look for examples of producers, consumers, and decomposers. Rotting logs are interesting examples of decomposition. A forest left in its natural state will contain tree trunks and branches in various stages of decomposition. Close examination will reveal the environmental factors that affect the rate of decomposition.

3. Discuss man's role as a consumer and a producer.

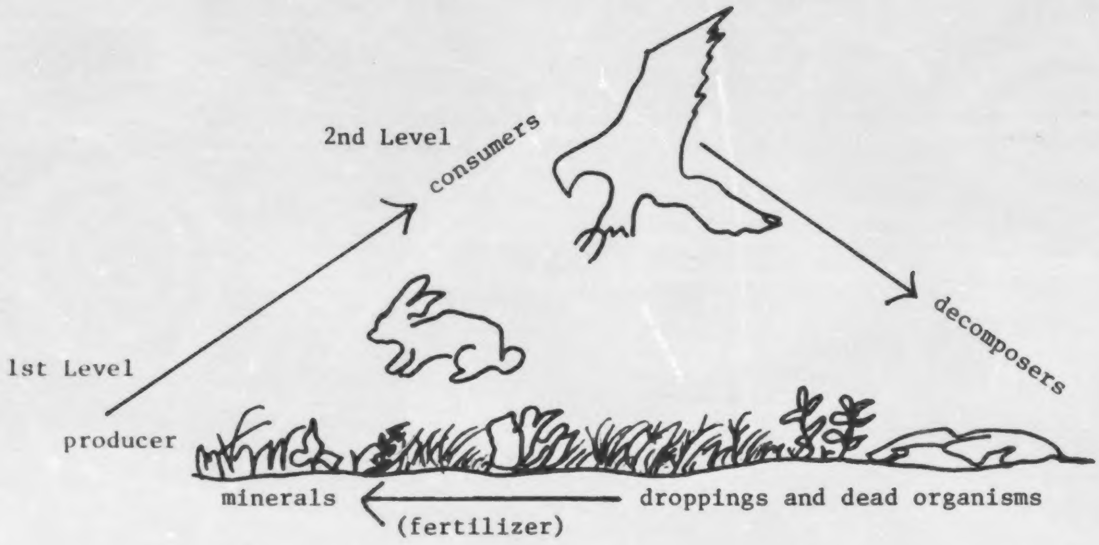
Instructional Objective	Concepts
Given a food chain or food web, identify the producer and various levels of consumers.	Food web Producer Consumer

Materials needed:

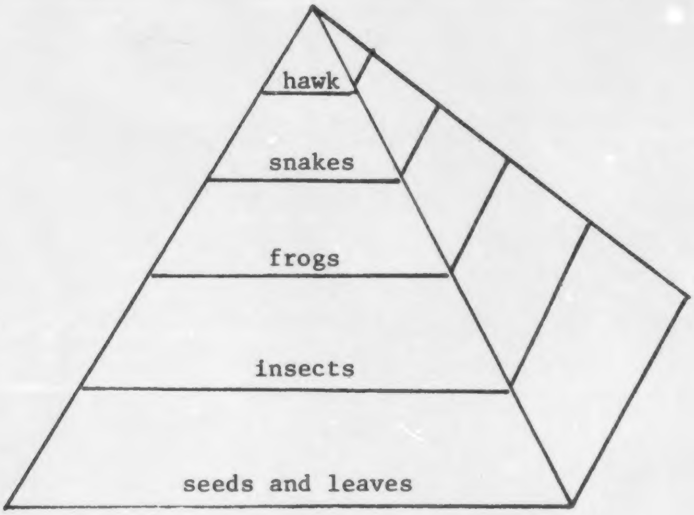
food webs from previous activity
reference materials
aquaria
terraria

Learning activities:

1. Use the food webs in the previous activity to have students classify the food sources as producers or consumers. Then have them classify all consumers as first level and second level consumers. Use one or more examples before asking them to use these terms to label a food web.


2nd Level
consumers
decomposers
1st Level
producer
minerals
(fertilizer)
droppings and dead organisms

2. Have students measure the food consumption of classroom animals. Let them estimate the amount of green plant food consumed in one day by the animals at the lowest level on the food web they constructed. Then let them calculate how much total food is consumed in one day the animal at the top of the web. Have students draw a food pyramid similar to the one below.


hawk
snakes
frogs
insects
seeds and leaves

Instructional Objective	Concept
Given an ecosystem, draw a diagram and explain the movement of matter and energy through a specific cycle.	Cycle

Materials needed:

aquaria and terraria
pictures of habitats
field experience
reference materials

Learning activities:

1. Have students observe a specific habitat in an aquarium, terrarium, a picture, or outdoors. "What part of the air do the plants use for making food? What do they give off in this process? What do the animals use when breathing? What do they give off?"

   Let students draw diagrams to show how the oxygen and carbon dioxide are used and produced by plants and animals.

   Ask, "Do plants also breathe oxygen?" Let students check references to compare the percentage of oxygen in the air to the percent of carbon dioxide in the air and discuss how this might affect the oxygen-carbon dioxide cycle and the lives of plants and animals.

2. Other cycles that affect the life of organisms in their environment are the nutrient cycle, the energy cycle, and the water cycle. Students may use reference material to find information for reports and for making charts. Provide opportunities for students to interpret the charts.

Instructional Objective	Concepts
Given the name of a plant or animal species, identify its niche in its environment.	Niche Predatory Prey

Materials needed:

terraria and aquaria
natural environments outdoors
pictures of organisms in their environments
list of organisms

Learning activities:

1. Choose a specific plant and animal species in a terraria or aquaria and ask, "What kinds of things does this organism do in its environment? How does it carry out its life processes? Is

it a producer, a consumer, or a decomposer? Is it a predator or is it prey? Does it have a special relationship with some other organism?"

During the discussion, develop the concept of a "niche." Define the word and give some examples. Provide a list of plant and animal species and let the students match the species names with their niches.

2. Give students the name of a species and have them brainstorm to name many roles the species can play in its environment.

3. Give students the names of niches and have them use reference sources to find the names of plant and animal species that fit the niche. Some suggested niches that can be investigated are:

predator
prey
producer
consumer
decomposer
parasite
saprophyte
scavenger

Instructional Objective

Given reference materials, identify man's role in his relation to the environment.

Concepts

Cycles
Pollution
Recycling
Conservation

Materials needed:

Reference materials
Films, filmstrips, pictures
Terraria
Aquaria

Learning activities:

# Have students work in small groups or individually to identify man's role in the natural environment. Use reference materials, aquaria and terraria, and outdoor experiences to find information and to reinforce concepts.

Some suggested activities are:

1. Have students make oral or written reports, scrapbooks, murals, or bulletin boards. Use films and filmstrips to generate discussion; use panels, debates, role play, and simulation games.

2. Use the services of a resource person, such as a conservation officer, an environmental education specialist, or other resource person. Utilize the opportunity to involve students in a resident camping experience. Visit outdoor education facilities, such as the Cincinnati Nature Center, Avon Woods, LaBoiteaux Woods, California Nature Preserve, or Burnet Woods.

3. Some suggested topics for investigation are:

- Waste disposal
- Man as a farmer
- Man as a builder
- Man as a producer
- Man as a consumer
- Water pollution
- The Environmental Protection Agency
- Recycling materials
- Conservation of soil, water
- Conservation of energy sources
- Endangered wild life
- Air pollution
- Noise pollution
- The National Wild Life Service

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For Pupils

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

2494	Adaptation in Plants
1732	Beaver
1561	Birds Migration
1232	Birds of Prey

Sound Films (Continued)

1863	Birds of the Countryside
1424	Birds of the Dooryard
1944	Birds That Eat Fish
1858	Birds That Eat Insects
1945	Birds That Eat Seeds
1865	Cecropia Moth
552	Desert Community, The
656	Discovering the Forest
659	Experimenting with Animals - White Rats
658	Fish in a Changing Environment
654	Green Plants and Sunlight
101	Hibernation and Other Forms of Dormancy
2546	Kentucky's Feathered Rainbow
553	Life Between Tides
1975	Life in the Forest
1991	Life in the Ocean
149	Life in the Woodlot
551	Life on the Tundra
169	Life Story of the Paramecium, The
549	Marsh Community, The
1390	Monarch Butterfly Story
2153	Plants Make Food
21	Plants Obtain Food
1992	Reptiles Are Interesting
650	Small Animals Protect Themselves
1448	Snakes Are Interesting
2193	Spiders
1899	Spring is an Adventure
657	Story of Discovery: Why Plants Bend Toward Light
214	Survivors, The: Surviving Ohio Wildlife
1542	Under Ohio Skies
1569	Wonders in a Country Stream

Filmstrips

6200	Climate and Plants
6148	Crocodilians and Turtles
7277	Desert, The: An Example of Adaptation (Plant and Animal Relationships)
5938-43	Exploring the World of Nature
7318	Food for Living Things (Learning About Living Things)
7233	How Plants Help Us (Plants: How They Live and Grow)
7360	Insects: Man's Greatest Rival
7317	Living Things Hard to See (Learning About Living Things)
7314	Living Things Need Each Other (Learning About Living Things)
6147	Non-Poisonous Snakes of the U. S.
7275-80	Plant and Animal Relationships
6146	Poisonous Snakes of the U. S.
6915	Water Life - Keeping an Aquarium
6912	Water Life - Life in Ponds, Lakes, and Streams
6916	Water Life - Plants and Strange Animals of the Sea

Loop Films

3529	Tidepool Life, Part I
3530	Tidepool Life, Part II

Mounted Pictures

10239	Reptiles and Amphibians
10237	Wildlife Conservation

A-V Media Approved for Purchase

Filmstrips

Encyclopaedia Britannica Educational Corporation

Discovering Life Around Us

A Visit to a Pond
A Visit to the Woods
A Visit to a Garden
A Visit to a Farm
A Visit to the Seashore

Learning About Living Things

Food for Living Things
Living Things Need Each Other

Living Things Through the Ages

How Plants and Animals Have Changed
The Age of the Earth and of Living Things
How Living Things are Adapted
How Adaptation Helps Living Things Survive

Plant and Animal Relationships

The Grassland: Story of a Major Community
The Swamp: Some Relationships Between Organisms
The Desert: An Example of Adaptation
The Seashore: A Continually Changing Environment
The Pond: How Living Things Change Their Environment
The Forest: A Stable Community

Houghton-Mifflin Company

Interaction in a Population (3 Filmstrips/Cassettes)

Adaptations
Population Needs
Ecological Interactions

Society for Visual Education

Exploring the World of Nature

Let's Explore a Field
Let's Explore a Garden
Let's Explore a Lawn
Let's Explore a Pond
Let's Explore a Stream
Let's Explore a Woodland

Popular Science Publishing Company

Nature's Disguises
Life in a Terrarium

True Book Physical Science

Deserts

Viewlex Educational Media

The Ecology of a Street (1 Filmstrip/Cassette)
The Ecology of a Park (1 Filmstrip/Cassette)

Study Prints

Instructional Supplements

18 x 13 inches 6 Pictures/Set

Set 5 Deserts of the World
Set 16 Forests

Silver Burdett Company

Science: Pictures That Teach: Understanding Your Environment
(14 Study Prints)

CONTINUATION OF LIFE

Background

Life is continued from one generation to the next by the process of reproduction. The life span of an individual organism varies from a few hours to over a hundred years. Species survive for thousands and millions of years through reproduction.

Life Cycles. The life cycle of individual organisms within a species follows a predictable pattern. Offspring are smaller than their parents. The young of some species resemble their parents in structure, but differ greatly in proportion and size of major body parts. Organisms, such as sponges, insects, and amphibians, have young that are greatly different in structure, habits, and diet from the adult. The process of development in which an organism changes form one or more times is called metamorphosis.

The metamorphosis of organisms, such as sponges and amphibians, consists of three stages--egg, larva, and adult. Some insects have four definite stages--egg, larva, pupa, and adult.

Methods of Reproduction. Biologists classify organisms by the structural features and methods of reproduction. Organisms are divided into kingdoms (plants and animals), classes, orders, families, genera, and species. Some scientists classify organisms, such as bacteria, euglena, and blue-green algae not as plants or animals but as members of a third kingdom, the "protist" kingdom. Methods of reproduction vary greatly among the different types of organisms.

Some kinds of organisms may be able to reproduce in more than one way. In general the reproductive methods fall into two categories: sexual and asexual. Sexual reproduction requires the union of an egg cell (ovum) and the sperm cell. Ordinarily these are contributed by separate individuals, although there are examples where both cells are contributed by the same individual. In asexual reproduction, a new organism is produced from existing parts of an organism.

The egg and sperm cells are gametes. The fertilized egg, capable of developing into a new individual organism, is called a zygote. A zygote develops into an embryo which develops further into a new, independent organism. Live bearers give birth to young whose embryo has developed inside the mother's body. With egg bearing animals, the embryo develops in the egg outside the mother's body. In some animals, such as amphibians and most fish, fertilization occurs externally, that is, outside the mother's body. In other animals, such as mammals, birds, reptiles, and some fish species, fertilization occurs internally.

Plants reproduce sexually and asexually. Some plants can reproduce in more than one way. The four asexual methods of plant reproduction are fission, budding, sporulation, and vegetative propagation. Fission and budding occur in the lower plants, such as algae, fungi, and yeast. Sporulation produces complete new plants in algae and fungi, but in mosses and ferns, sporulation produces gametes which unite to form a fertilized egg which grows into a spore-producing mature plant.

Vegetative propagation is a process in which a part of a plant grows into a complete new plant. This takes place because a whole plant can be regenerated from a part. Missing parts are formed from other parts. Stems, leaves, roots, and flowers may be propagated into a new plant. Bulbs, rhizomes, corms, runners, tubers, and cuttings can all be used to propagate new plants. Grafting of a stem of one plant into a stem of another is a common propagation technique used with fruit trees and ornamental trees.

Heredity. Inherited traits of organisms are transmitted to offspring through genes. Genes are present within the chromosomes found in the nuclei of all cells. Genes determine the sex, color, size, and shape of organisms and parts of organisms. Each gene is a segment of a DNA (deoxyribonucleic acid) molecule.

New varieties of plants and animals are developed through cross breeding. Hybrids are animals or plants that are produced by parents that have different hereditary traits. Mutants are organisms that result from changes in genes. New varieties of cattle, corn, wheat, roses, and other farm and garden products are being developed through selective cross-breeding. The traits of offsprings can be predicted statistically when the traits of the parents are known and the dominance and recessiveness of these traits are known.

Reproductive Methods

fission	cell division in which the cell splits into two or more parts, each of which becomes a new life
conjugation	a temporary joining together of cells in which micro-nuclei are exchanged
budding	the new plant or animal forms from a small mass or bud on the parent
fragmentation	the parent breaks into two or more parts each of which grows into a new organism
regeneration	growing back of a lost part
sporulation	the production of spores which can grow into new organisms
vegetative propagation	an asexual method of reproduction in which a part of a plant can develop missing parts and grow into a new, independent plant
sexual generation	the new organism is formed by the joining together of two sex cells which are usually contributed by separate organisms
polyembryony	single egg twinning

hermaphroditic	both male and female cells produced by the same organism
internal fertilization	the joining of egg and sperm inside the female
external fertilization	the joining of egg and sperm outside the body of the female

The following chart lists the major plant and animal groups and indicates the reproductive method of each group.

Kind	Reproduction Method(s)
amoeba, paramecia	binary fission, conjugation
sponges	budding
jelly fish, anemones, choral	fission, budding, sexual generation
sea lillies, starfish, sea urchins, sea cucumbers	budding, fragmentation
snails, clams, octopuses	sexual generation, hermaphroditic
earthworms	fragmentation-regeneration, sexual generation, hermaphroditic
spiders, insects, centipedes, millipedes	sexual generation
fish, amphibians, birds, reptiles, mammals	sexual generation, polyembryony (single egg twinning)
algae	fission and sexual generation
yeast	budding and fission
fungi	spores
mosses	spores and gametes; sexual generation in two stages
ferns	sporulation and sexual generation in two stages
gymnosperms (cone bearing plants)	seed producing, sexual generation and vegetative propagation
angiosperms (flowering plants)	seed producing, sexual generation and vegetative propagation

Rationale

The unit Continuation of Life is designed to help students (1) observe and describe the life cycles of organisms, (2) investigate the various methods of reproduction, and (3) investigate the effect of heredity, environment, and learning on the properties and behaviors of organisms. The topic is one that has immediate appeal and interest for most students. It offers opportunities for understanding interrelationships between organisms and their environment. Studying life cycles of organisms offers the opportunity to reinforce concepts of life science developed earlier. It provides the opportunity to learn from first-hand experience with organisms in the classroom and outdoors. It provides knowledge and experiences that can help students develop a healthy respect for life.

This study provides students with information, vocabulary, and a perspective that is most helpful in dealing with human reproduction. It is highly recommended that material from Continuation of Life be used prior to or concurrently with material in the Health Curriculum on Human Growth and Development.

Glossary of Concepts

Culture	Organisms being cultivated or reared for supply.
Growth	An increase in size of an organism due to an increase in the number of cells.
Development	Passing from one stage of maturation to another with the appearance of new structures.
Metamorphosis	The change in form (body structure) that occurs in the development of animals in which body structure of the young is different from the adult.
Life Cycle	The sequence of stages in the development of an organism from egg to adult to egg.
Genetic Identity	The similarity between adults and offspring.
Generation	All organisms of the same kind born about the same time.
Reproduction	The process by which plants and animals produce other organisms like themselves.
Asexual Reproduction	A kind of reproduction that does not involve the union of male and female reproductive cells.
Vegetative Propagation	Reproduction of plants from parts other than seeds.

Flower	The part of a seed plant that contains the reproductive organs.
Pollination	Transfer of pollen from stamen to stigma of flowers to fertilize eggs.
Fertilization	The joining together of sperm and egg.
Gametes	The sex cells; the sperm or male cell, and the ovum (egg) or female cell.
Zygote	A fertilized egg which is capable of growing into a new organism.
Sexual Reproduction	Reproduction by the fusion of a male sex cell (sperm) with a female sex cell (egg).
Seed	A dormant stage of development in the sexual reproduction of plants.
Embryo	An animal prior to birth or hatching; the immature plant in a seed.
Germination	The beginning of growth of a seed or spore.
Fruit	Ripened ovary of the flower.
Gestation	The period of carrying young from fertilization (conception) to birth.
Trait	A distinguishing characteristic of an organism.
Heredity	Passing of traits from parents to offspring through genes.
Hybrid	New variety of flower made by selective breeding.

Investigations

Instructional Objective	Concept
Given appropriate materials, prepare cultures of organisms.	Culture

Learning activities:

1. Involve students in developing cultures of many different organisms. This is essential to almost every other activity in the unit. Specific instructions are provided below.

   Introduce the word "culture." As students prepare to develop cultures, use the word to emphasize its meaning. For example, speak of "the fruit fly culture" or the "mealworm culture."

2. As pupils prepare cultures they have many opportunities to develop understanding and appreciation of Career Motivation Objectives, such as doing purposeful work, purchasing supplies, assuming the responsibilities for completing a task, having the satisfaction of doing a job well, experiencing and learning about the division of labor and the interdependence of different jobs.

CAUTION

Animals are protected from harm by state and federal law. Classroom animals should be kept under excellent conditions. Attention should be given to assure that classroom animals have proper diet, proper housing, proper temperature, and be kept clean. No experiments should be conducted with vertebrate animals that would deprive them of excellent care or cause them to die.

Instruction for Culturing Organisms

Fruit Flies

Materials needed:

- jars
- cloth
- rubber bands
- labels
- plastic vials
- decaying fruit (apple or banana)

Learning activity:

Put a piece of decaying fruit in a wide mouth container. Place it by an open window or outdoors. Shortly, fruit flies will probably collect in and around the jar. Place a piece of cloth over the mouth of the jar and fasten it with a rubber band. The fruit flies will reproduce rapidly. As the population increases, students may transfer some of the fruit flies to plastic vials containing fruit. Each student may have his own culture to observe and care for.

Mealworms

Materials needed:

- jars, plastic bags or other containers
- bran or oatmeal
- mealworms
- potato

Learning activity:

Obtain mealworms from pet supply or bait shop. Place mealworms in a jar containing bran or oatmeal. Cut a potato in half. Place both halves on top of the bran. The potato provides moisture and a place for the mealworms to lay eggs. If possible, keep in a cool place to slow development.

Other Insects

Materials needed:

glass, plastic or wire screen containers
cheese cloth
food (leaves, fruit)

Learning activities:

Students may wish to obtain specimens of other insects to observe their life cycles. Ants, moths, butterflies, house flies are easily obtainable and provide rich experiences for students.

Ants may be dug almost any place. Larvae and pupae are not difficult to find. Children should be discouraged from bringing in the queen ant because she is necessary for the preservation of the colony. She is easily identified because of her large size.

Moths and butterfly caterpillars are easily obtained. Children should bring in leaves of the plant on which the caterpillar is found. Glass, plastic, boxes or wire-screen containers are suitable.

House flies may be captured in large glass jars with food material (sugar, fruit, etc.) as bait. Flies will be easier to obtain in the fall than in the spring. A sleeve made of cheese cloth may be tied to the top of the jar. Tie the other end of the sleeve also. Students may untie the loose end and slip their hands in to care for the flies. Use care so that flies do not get out and become pests.

Rodents

Materials needed:

metal animal cage or glass aquarium with exercise wheel
litter
food
water bottle
rodents
reference materials

Learning activities:

Mammals require the most care of all organisms suitable for classrooms. Any rodent will bite, therefore there is always a certain amount of risk involved. Gerbils are probably the safest to handle, are the easiest to care for, are odor free and reproduce quickly. Mice, hamsters, and rats are also usable but require a great deal of care and caution. Guinea pigs make excellent classroom animals and pets; however, their gestation period is long.

Refer to books on the care and classroom application of specific rodents.

Fish

Materials needed:

one 5 to 10 gallon aquarium complete with filter, heater, and water pump
eight to twelve 1 or 2 gallon aquaria (or plastic shoe boxes)
clean sand
aquarium plants
guppies (or other tropical fish)

Learning activity:

Every science room should have an aquarium. However, for the study of life cycles it is preferable that students have small individual aquaria to observe. One or two gallon aquaria or plastic shoe boxes make good small aquaria.

Have each group set up its own aquarium, record observations, and assume responsibility for the care of the organisms. If more than one class is using the same materials, let each class return the materials to central storage containers until all students have assembled aquaria. Then assign specific groups to specific aquaria for observation. Assign one class to feed the fish each week so that fish are not over fed.

Provision should be made to take care of the fish on weekends. Place the fish in a heated tank and return them to the individual aquaria on Monday.

Frogs

Materials needed:

frog eggs
pond water
algae
lettuce
egg yolk
turtle food

Learning activity:

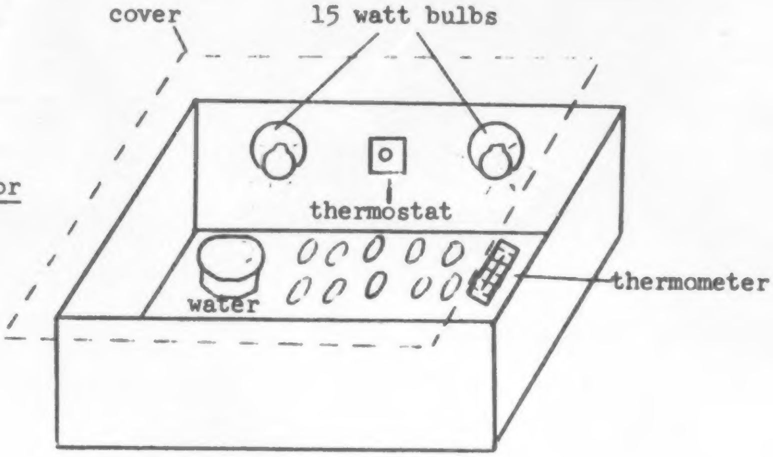
Frog eggs may be collected in early spring in ponds, lakes, and small streams. Place the eggs in a jar of pond water. When tadpoles hatch, feed them algae or small pieces of lettuce. As they develop, tadpoles will also eat boiled egg yolks, fish food, or turtle food. As they mature, they become meat eaters and will no longer be satisfied with plants alone.

Chickens

Materials needed:

5 to 10 gallon aquarium, or plastic or wooden box
one 25 watt bulb or two 15 watt bulbs (incandescent)
thermostat
soft cloth
container
fertile eggs

Incubator



Learning activities:

Hatching baby chicks is an exciting and rewarding activity for students. However, do not attempt it if equipment is not available or if there is no way to care for the chicks after they hatch.

Incubators may be made from a variety of containers. A 5 to 10 gallon aquarium, a wooden box, or a plastic container works well. One 25 watt bulb or two 15 watt bulbs provide the heat source. Temperature must be kept at a constant 30° C. Variation of more than two degrees from this temperature will prevent the eggs from hatching. An opening with a sliding cover can be used to regulate the temperature. A good thermostat connected in series with the heat source is desirable. Place a thermometer at egg level and shield it from direct light. Place a towel or other soft cloth in the bottom of the incubator.

Obtain fertile eggs from a hatchery. Use a magic marker to mark one side of the egg so that students can keep track as they turn the eggs. The eggs must be turned twice a day to prevent the developing embryos from sticking to egg membranes.

Developing embryos may be observed by carefully picking away the sides of a shell. Try not to break the thin membrane just beheath the shell. If an egg breaks accidentally or if the class decides to break an egg in the early stages of development, it will offer a good opportunity to observe the beating heart, the developing circulatory system and the eye spot. Embryos may be preserved in a small jar of alcohol or formalin. Place a label on the jar showing the number of days of development.

During the nineteenth and twentieth days, moisten the eggs with water to facilitate hatching. Do not try to help the chicks out by cracking the shells. Let the chicks struggle on their own. This exercise is essential to the chick's survival and development.

Molds

Materials needed:

- bread
- water
- petri dish or plastic bag
- paper or gummed labels

Learning activity:

Give each student a piece of bread and a plastic bag. Instruct the students to rub the bread across a surface and place it in the plastic bag, add water, and put it in a place of his choice.

Have each child write his name, the date, the surface rubbed, and the place stored on a label and place it with his experiment. Have him keep a diary of what happens each day. Students may compare experiments and identify the variables that affected the mold growth.

Ask questions such as "What did the mold look like when it first appeared?" and "What color changes did it go through?"

Mosses

Materials needed:

- mosses
- soil
- humus (peat moss)
- pot, terrarium or other container

Learning activity:

Place a mixture of rich soil and humus into a flower pot and water well. Shake some spore cases from growing moss on the soil and place pot in a spot that has medium light. Cover the pot with a piece of glass to prevent water in soil from evaporating too quickly; water as often as necessary to keep the soil constantly moist. Moss will grow in a few weeks. Draw a diagram to show the life cycle of the moss.

Moss is a good terrarium plant. A sample of moss placed in a closed or partially closed jar will usually survive very well. The life cycle of mosses is very complex. Both sexual and asexual reproduction are used. The sporophytes disperse spores which develop into gametophytes which reproduce sexually. With a hand lens the sporophytes and gametophytes may be observed.

Algae

Materials needed:

- containers
- water (aged)
- light source
- algae

Learning activity:

Visit a pond, lake, or stream. Collect algae if available. If algae is not found, collect water and keep under a light. Algae should appear within a week or two. There are many types of algae available in most ponds. Collect as many kinds as possible. Lettuce or white toilet tissue will help induce growth of algae.

Yeast

Materials needed:

- water
- dextrose or cane sugar
- yeast--dry or cake
- microscope or microprojector

Learning activity:

Place a small amount of yeast in a container of water. Add dextrose. The yeast will change the sugar into alcohol which will eventually kill the yeast. Let students try to start new cultures from the old to keep the yeast alive. Ask students, "Can you tell when the culture dies? Why do you think it dies? How could you keep it alive?" Observe with a microscope or microprojector.

Flowering Plants

Materials needed:

seeds (pumpkin, bean, tomato, radish, corn, dandelion, bird seed)
soil
containers
water

Learning activity:

Let students plant seeds of various kinds in containers. A miniature garden can be developed by putting soil in a used plastic wading pool and planting seeds in it. A bird seed garden is an interesting experience for children.

Instructional Objective

Given plant and animal cultures, record observations of the life cycles of the various organisms.

Concepts

Growth
Development
Metamorphosis
Life cycles

Materials needed:

animal and plant cultures
reference books, filmstrips, films, pictures
art supplies

Learning activities:

1. As students observe cultures, have them record pertinent data such as the number of organisms, the length or height, weight, the appearance of new parts, and changes in color. Records should include dates. Picture records, graphs, charts, data sheets, and written descriptions are all valuable means of recording data.

   Films, filmstrips, study prints, and transparencies will be useful in helping students observe the life cycles of organisms. These may be used with individuals, small groups, and large groups.

2. Let students record observations of the growth and development of organisms. Picture records with dates are valuable. So are graphs and charts.

   Life cycles of insects and amphibians are good examples of "metamorphosis." Students may wish to draw pictures of each state of development on a separate card. Mix them up and have a partner put them in order.

Instructional Objective | Concepts

Given pictures of organisms, compare the properties of the offspring with those of their parents.

Genetic identity
Generation

Materials needed:

pictures of organisms, adults, and their young
classroom organisms

Learning activity:

Provide students with pictures of organisms and their offspring. Ask, "How are the young like their parents?" "How are they different?"

Have students record the length of an animal at birth and compare it to the length of one of its parents. The students can calculate the ratio of the length and weight of the offspring.

Introduce the concepts of "genetic identity" and "generation." Define them and use the terms as you investigate organisms and their offspring.

Instructional Objective | Concept

Given the names of organisms and references, find ways organisms reproduce.

Reproduction

Materials needed:

reference books and other media

Learning activities:

1. Provide students with a list of names of plant and animal species and reference materials. Let them identify the way each organism reproduces and record these on a chart. The chart may look something like the following:

paramecia	fission
algae	fission, spores, gametes
yeasts	budding

mushrooms	spores
mosses, ferns	spores
earthworms	live birth in cocoon
snakes	eggs, live birth
potatoes	eyes
carrots	seeds, roots
fish	live birth, eggs
maple trees	seeds
forsythia	seeds, cuttings
apple trees	seeds, grafting

2. A variation of this activity is to provide students with the names of the organism and the name of the method of reproduction and have students match them.

3. Another variation is to give students the names of the reproductive methods and have them find examples of organisms that use that method in reference books.

Instructional Objective	Concept
Given a collection of plants, start new plants by vegetative propagation.	Vegetative propagation Asexual reproduction

Materials needed:

- potatoes with eyes
- African violets
- onion or narcissus bulb
- coleus plant
- carrot
- sweet potato
- twigs of willow or forsythia
- strawberry plant (wild or domestic)
- containers
- soil
- sand
- rock chips
- reference books

Learning activities:

1. Provide students with many kinds of plants that can be propagated by planting parts. Have students start plants in as many ways as they can. Encourage them to find the proper names for the parts they use. Some students may wish to investigate the process and application of grafting.

   Introduce the term "vegetative propagation" and relate it to the concept of "asexual reproduction."

Parts of plants used in vegetative reproduction are:

Parts:	Plants:
bulbs	onions, tulips, lillies, narcissus
corms	gladiolus
rhizomes	grass, iris
stems, tubers	coleus, potato (eye)
twigs	willow, forsythia, fruit trees (grafting)
roots	carrot, sweet potato
leaves	African violet, geranium

2. Give the students a list of plant parts. Have them find the names of plants that can be propagated from each part.

Instructional Objective	Concept
Given a plant, identify the part that is a flower.	Flower

Materials needed:

flower collection--suggested flowers

tulip
dandelion
rose
grass
violet
maple
oak
apple
dogwood

hand lenses

Learning activities:

1. Students can usually identify flowers that are relatively large and brightly colored. Take students outdoors in the spring, or provide a collection of flowers for students to examine. Show them a maple tree just turning green. Ask, "What are those green objects coming from the trees?" Let them examine them closely. See if they can find the stamen and pistils of the flowers. Then let them examine other plants. Show them a yellow dandelion head. Ask, "How many stamen and how many pistils do you see? What is at the base of each pistil? How many flowers are in the yellow head?" The dandelion head is compiled of many separate flowers. Examine the dogwood blossom. Ask, "How many separate flowers can you find? Are the stamen and pistils together? Where are the stamen? Where are the pistils?"

2. Let students try to define "flower" in terms of its structure.

Instructional Objective	Concepts
Given a flower, dissect it, name its parts, and describe how it produces seeds.	Pollination Fertilization Gamete Zygote Sexual reproduction

Materials needed:

flowers (spring blossoms work best)
newspaper
worksheet or plain paper
paper towel
microscope or microprojector
microscope slides

Learning activities:

1. Distribute flowers to small groups or a whole class. Have students place the flower on a piece of newspaper. Instruct them to carefully pull off the sepal and petals and lay them on a piece of paper or paper towel. Have them write the correct name beside each part. Do the same for the stamen and pistil. Let them open the ovary and find the eggs. Label them also. Have the students draw a picture of a flower, cut away to show its parts. Have them label each part. The teacher may wish to prepare a worksheet with a drawing and have students label the parts of a flower.

2. Let students examine the pollen grains under a microscope or microprojector. Let them draw pictures of the pollen grains and label them by name.

3. Have students compare the parts of many different kinds of flowers and predict whether the flower can pollinate itself or whether outside agents, such as insects or the wind, are necessary. Discuss cross pollination.

   Let students read and view films and filmstrips on pollination and seed making. Use the flower picture and/or the dissected flowers to help them describe the process of pollination. Discuss cross-pollination, sperm, ovule, fruit, and seed. The teacher may also wish to introduce the words "gamete" and "zygote" at this time. All of the above terms are useful in developing the concept of "sexual reproduction." As this is done, it is helpful to distinguish it from the various types of "asexual reproduction."

4. Have students use reference materials to identify organisms that reproduce both sexually and asexually.

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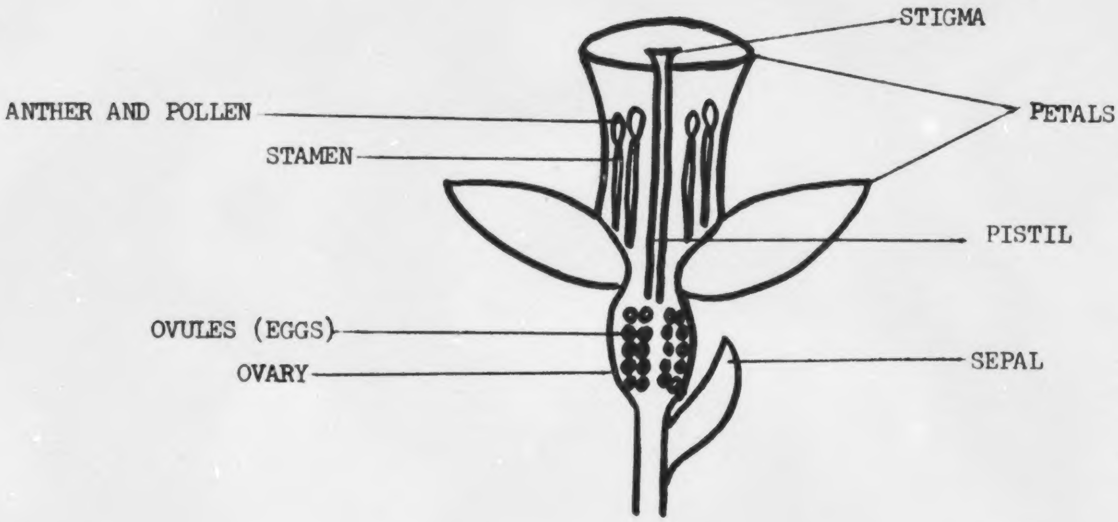

Instructional Objective

Given a seed, dissect it, and name its parts.

Concepts

Seed
Embryo

Materials needed:

dried lima beans
newspapers
hand lens

Learning activity:

Soak beans overnight in water. Distribute beans to a small group or entire class. Instruct students to take the seed apart, lay the parts on a piece of newspaper. Have them draw the parts on a piece of paper and label them. Let them find the names of the parts in a reference book or tell them the names if necessary. Introduce the words "cotyledons," "embryo," and "seedcoat." Discuss their meanings.

Instructional Objective

Given seeds, identify variables that affect their germination and growth.

Concept

Germination

Materials needed:

- seed collection--suggested seeds
  - beans (lima, green, pinto, mung, or other varieties)
  - peas
  - radish
  - pumpkin
  - lettuce

Materials needed: (continued)

- soil
- sand
- gravel
- peat moss
- glass or plastic jars
- empty milk cartons
- paper towel or cloth
- water

Learning activities:

1. Divide a lima bean in half. Plant each half in soil. Plant an embryo. Record results. Compare the results of planting bean parts to the growth of a whole bean.

2. Place a paper towel or a cloth inside a glass or plastic jar. Put a little water in the bottom of the jar. Place some seeds between the towel and the sides of the container. Refer to the beginning of growth as "germination." Observe the growth over a period of days. Record the time it took each seed to begin growing. This is the germination time. Find the average germination time for each kind of seed. Ask the children to identify the variables that may have affected the germination time (type of seed, amount of water, amount of temperature, amount of light). The teacher and students may wish to design experiments to test the effect of each variable on the germination time.

3. Have students plant seeds in various combinations of materials (soil, sand, gravel, peat moss). Let them test the hypothesis that the type of soil affects germination time.

4. Have each student plant one or more seeds and keep a picture record or a graph of its growth. Students may conduct experiments varying the soil, water, light, temperature, plant food, or other environmental factors to determine the variables most conducive to good plant growth.

Instructional Objective	Concept
Given a collection of fruits, identify each item as a fruit and investigate its parts.	Fruit

Materials needed:

- suggested fruits--
    - orange
    - apple
    - green beans (mature and immature)
    - iris or other spring flowers

Materials needed: (continued)

suggested fruits (continued)
- corn
- sunflower
- dandelion

reference books

Learning activities:

1. The technical definition of a fruit can be approached by examining the fruit of the many kinds of plants. Have students compare the various fruits in the collection. Let them classify them by properties, such as those having interior seeds and those having exterior seeds. Ask students to show you a dandelion fruit, a corn fruit, or a sunflower fruit.

   Let students find definitions of the word fruit in a variety of reference sources. Define "fruit" as the mature ovary of a plant. Some of the objects which look like seeds (sunflower, dandelion, and corn) are actually fruits. Distinguish this concept of fruit from the common usage of the words fruit and vegetable. For example, make sure that students identify the green bean as the fruit of the bean plant although we commonly refer to it as a vegetable.

2. Open some of the fruits and investigate the parts. Ask, "Can you find eggs in beans and other fruits that were not fertilized and did not develop into seeds?"

Instructional Objective	Concept
Given a species of a vertebrate animal, describe or illustrate its reproductive cycle.	Animal reproduction

Materials needed:

reference materials

Learning activity:

Let students choose a vertebrate animal, find information on its reproductive cycle in encyclopedias, supplementary book or text book, and report it to the class. The information may include the following: whether fertilization occurs internally or externally; whether it hatches from an egg or is live born; appearance of young at birth; rate of growth; age at which it is able to reproduce; metamorphosis, if any; care given by parents; and training given by parents.

It should be noted here that human growth and development is a major thrust in the Health Curriculum of the Cincinnati Public Schools.

Instructional Objective	Concept
Given pictures or names of animals, classify animal mothers according to those that lay eggs and those that do not.	Egg

Materials needed:

reference books, filmstrips, etc.

Learning activity:

Provide students with pictures or names of at least ten different animals. Let them enter the animal names on a data sheet, classifying animals that lay eggs and animals that do not lay eggs. The first attempt should be on the basis of experience. A second attempt may be made after students have seen filmstrips, read books, or used other media.

Animals That Lay Eggs	Animals That Do Not Lay Eggs

Suggested animals:
- goldfish
- guppies
- grasshopper
- paramecium
- rattlesnake
- earthworm
- platypus
- robin
- frog
- hydra
- rabbit

Instructional Objective	Concept
Given a list of animals, record their gestation period and identify the variables that affect them.	Gestation

Materials needed:

reference materials

Learning activity:

Give students a list of animal names. Let them find the gestation period for each organism. Have the students describe the organisms by their properties, then try to infer any relationships between those properties and the gestation period.

Ask students to compare the properties of the young born to animals having a short gestation period to those having a long gestation period.

Instructional Objective	Concept
Given a plant or animal and reference materials, describe the traits of different varieties of the species.	Trait

Materials needed:

garden catalogs
encyclopedias, other reference books, and media

Learning activity:

Assign or have each student choose a species of a plant or animal and locate in a number of reference sources as many varieties of that as he can. Especially valuable are encyclopedias, books, or articles on dogs, cats, horses, mice, and other animals. Garden seed catalogs are also helpful.

Introduce the word "trait." Have students describe the traits of the organisms they chose. This can be done orally, in writing, or as a chart.

Instructional Objective	Concepts
Given the name of a plant or animal species and reference materials, identify the variables that affect the traits of the species and report how the variables affect traits.	Heredity Hybrid

Materials needed:

reference books and other media
growing plants
fruit fly cultures

Learning activities:

1. Classify the traits listed in the previous activity as to which of the following variables contribute to their development: heredity, environment, or learning.

2. Let students look up related topics in reference books to gather information about the effect of heredity, environment, and learning on the traits of plants and animals. The following questions may be used to stimulate further investigation.

   Heredity

   "Can parents produce offspring that have different traits from themselves?" "How do genes affect the traits of offspring?" "What are dominant and recessive characteristics and how do they affect offspring?" "What is a pure line?" What is a hybrid?" How are new varieties developed?" "What is a mutant?" "What physical traits did you inherit from your parents?"

Environment

"What traits can be affected by environmental factors?" "Which environmental factors can affect the growth of plants?" "Animals?" "How important is diet to the growth and well being of animals?" "How does diet affect offspring?"

Learning

"What kinds of traits can be developed by learning?" "Structure?" "Behavior?" "What skills have you learned that you could not have inherited?" "Is being able to run fast affected only by learning?" "To what extent do you think being able to run fast is inherited?"

3. Have students draw diagrams illustrating how traits can be passed on to succeeding generations. Use examples of dominant and recessive characteristics and examples where blending results from genes that are neither dominant nor recessive.

4. Students and teachers who are interested in studying the genetic phenomena directly may wish to culture fruit flies, cross them, and observe the offspring for two or more generations.

Instructional Objective	Concept
Given reference sources, communicate information about careers that involve the growth and reproduction of organisms.	Careers

Materials needed:

reference materials
art supplies

Learning activities:

# 1. Take a field trip to a nursery, truck farm, orchard, or other business in which plants are propagated in different ways. Make a chart or a display showing different ways that plants are propagated. Make a chart showing people whose jobs are related to plant or animal reproduction.

# 2. Visit a poultry hatchery to learn about the variables and controls used in a commercial hatching of poultry.

# 3. Use reference materials to find information about the careers that involve growth and reproduction. Some suggested topics are: horticulture; animal husbandry; genetic research; fish hatcheries; grafting; biological supply companies and the like.

# 4. Invite a person to the class whose occupation is related to plant or animal reproduction, such as a nursery man, flower grower, fruit grower, farmer, zoo keeper, veterinarian, and the like. Be specific about what you want the person to talk about, such as what his job entails, what training he has had, and the skills that are needed. It will help if the person knows what experiences the class has had and some idea about the seven developmental areas of Career Motivation.

# 5. Obtain the film "Room to Grow" from the Cincinnati Garden Center. The film shows many occupations in horticulture.

# 6. Encourage students to take part in community garden activities, such as Operation Green Thumb. Call the Cincinnati Garden Center or the Cincinnati Recreation Commission.

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Mediography

Materials listed in A-V Media Handbook - 1972

Sound Films

1865	Cecropia Moth
150	Darwin's Finches
5	Flower and the Hive, The
655	Flowering Plants and Their Parts
1019	Flowers at Work
169	Life Story of the Paramecium, The
1390	Monarch Butterfly Story
1774	Planting Our Garden

Sound Films (Continued)

100	Plants that Grow from Leaves, Stems, and Roots
2221	Reproduction in Mammals
1692	Salmon Story
1899	Spring is an Adventure
1775	Taking Care of Our Garden
213	Wonder of Reproduction

Filmstrips

7318	Food for Living Things (Learning About Living Things)
7319	How Life Continues (Learning About Living Things)
7358	How Plants Spread and Reproduce
7232	How Plants Start Growing (Plants: How They Live and Grow)
7286-90	Insect Life Cycles
7393-97	Insect Life Cycles
7228-33	Plants: How They Live and Grow
7182	Story of the Atlantic Salmon

Loop Films

3598	Germination of the Bean
3552	Flowers Opening

A-V Media Approved for Purchase

Filmstrips

Encyclopaedia Britannica Educational Corporation

Learning About Living Things

How Life Continues

Insect Life Cycles

Beetles and Their Life Cycle
The Grasshopper
The Honeybee and Its Life Cycle
Monarch Butterfly

Popular Science Publishing Company

The Function of a Flower

Society for Visual Education

Role of Flowers and Fruits (Filmstrip/Recording)

Flowers: Their Parts and Function
Fruits: Their Growth and Classification

Houghton Mifflin Company

Interaction in a Population (3 Filmstrips/Cassettes)

Loop Films

Doubleday Multimedia

1101	Caterpillar to Moth
1114	Goldfish Eggs Hatching

Ward's Natural Science Establishment

73W0100	Germination of the Bean
73W3000	Flowers Opening

Transparencies

Instructo Products Company

816-1	Life Cycle - Frog
816-2	Life Cycle - Butterfly
816-13	The Bee Hive
917-3	From Flower to Fruit

Study Prints

Society for Visual Education

SP101	Spring Wild Flowers
SP107	Moths and Butterflies
SP108	Common Fruits, Group 1
SP110	Animals Without Backbones
SP117	Familiar Birds--Their Young and Nests